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INDIAN JOURNAL OF POWER & RIVER VALLEY DEVELOPMENT

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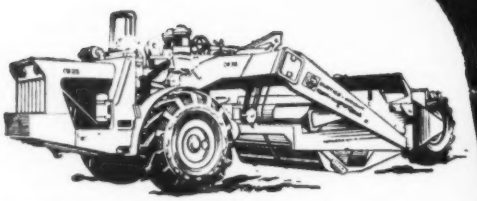

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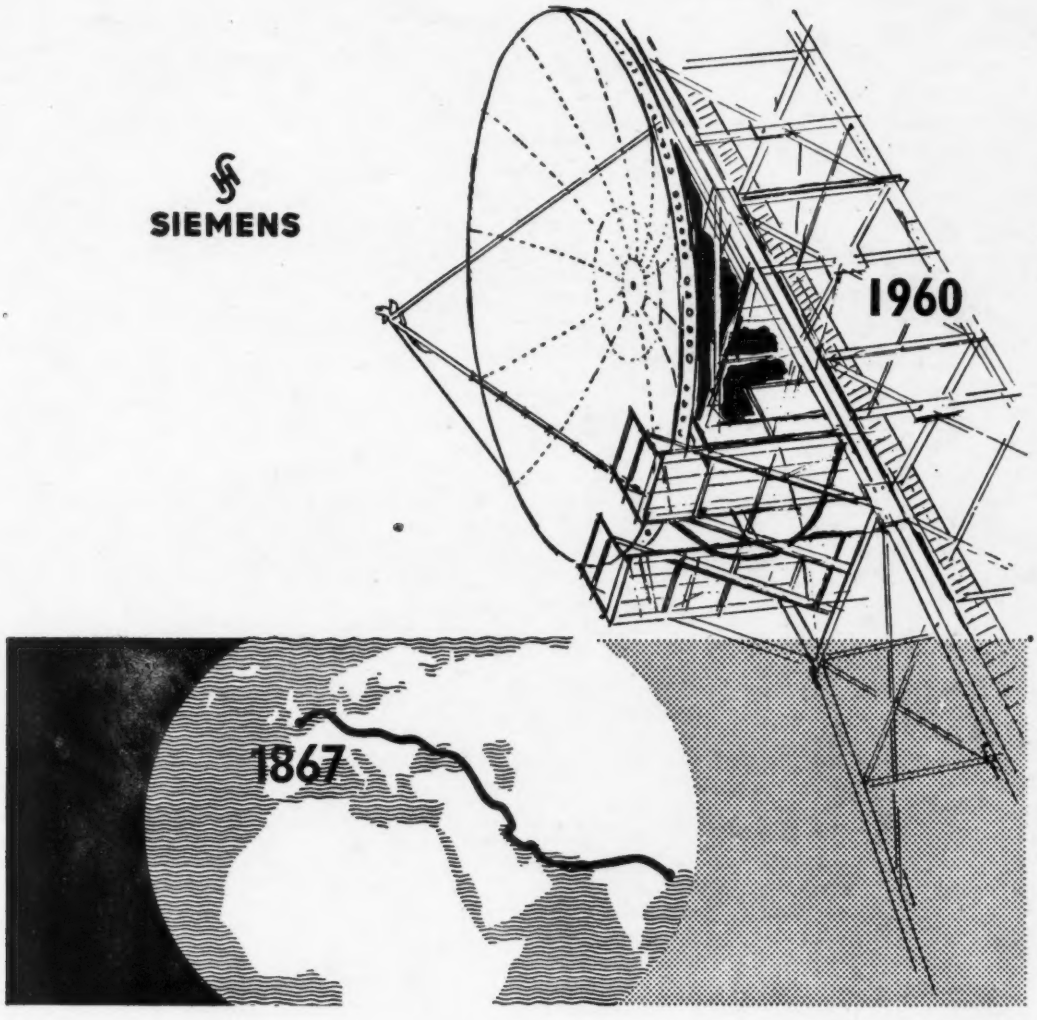

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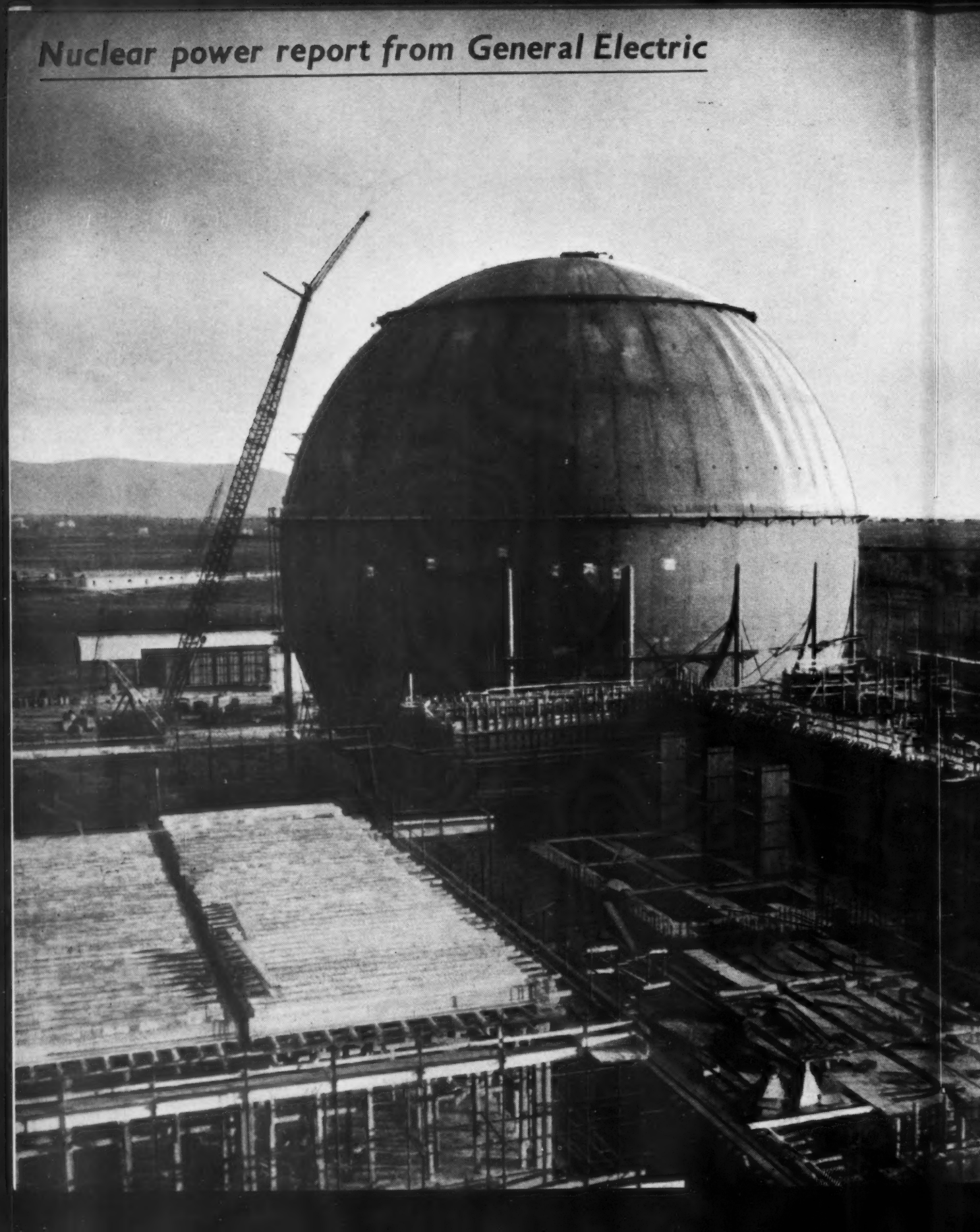
Nuclear power report from General Electric



Excellent progress being made around the world on General Electric boiling water reactor projects

North of Naples, Italy, on the Garigliano River, construction of the 150,000 kw nuclear power plant for SENN recently passed the halfway point. The General Electric design was selected by SENN for the nuclear power reactor after a seven man international team of nuclear experts analyzed the reactor proposals made by nine groups. The evaluation showed that the G-E boiling water reactor, using enriched uranium fuel, would provide the lowest power costs of all reactor concepts, and the simplicity of the G-E BWR design would require the lowest possible capital investment. The plant allows for an increase of 50% in kw output without major construction changes.

On the other side of the globe, General Electric Japan, Ltd. is building a direct-cycle boiling water reactor for the 12,500 kwe plant at Tokai Mura, Japan, for the Japanese Atomic Energy Research Institute (JAERI). This plant, designated JPDR, is expected to be the first nuclear power generating plant in the Far East and is presently on schedule.

In the U.S.A. two more nuclear power stations, using the G-E BWR, are under construction and on schedule. One is located at Big Rock Point on Lake Michigan and the other at the Humboldt Bay Power Plant site near Eureka, California.

Long identified as a leader in atomic development, G.E. is engaged in a widely diversified program of nuclear application. BWR plants are now being offered up to 500 megawatts, incorporating such advanced concepts as high-power density cores, pressure suppression containment and internal steam separation. Other atomic products and services include reactor subsystems, components, fuel, control and instrumentation, engineering studies, computer services, research, development and irradiation services. *For further information write to International General Electric Company, Dept. 30-20 R, 159 Madison Avenue, New York 16, N. Y., U.S.A.*

◀***The giant 160-foot containment sphere*** of the Garigliano Nuclear Power Station in Italy. The sphere, twice the size of St. Peter's dome, will house the G-E dual-cycle boiling water reactor.

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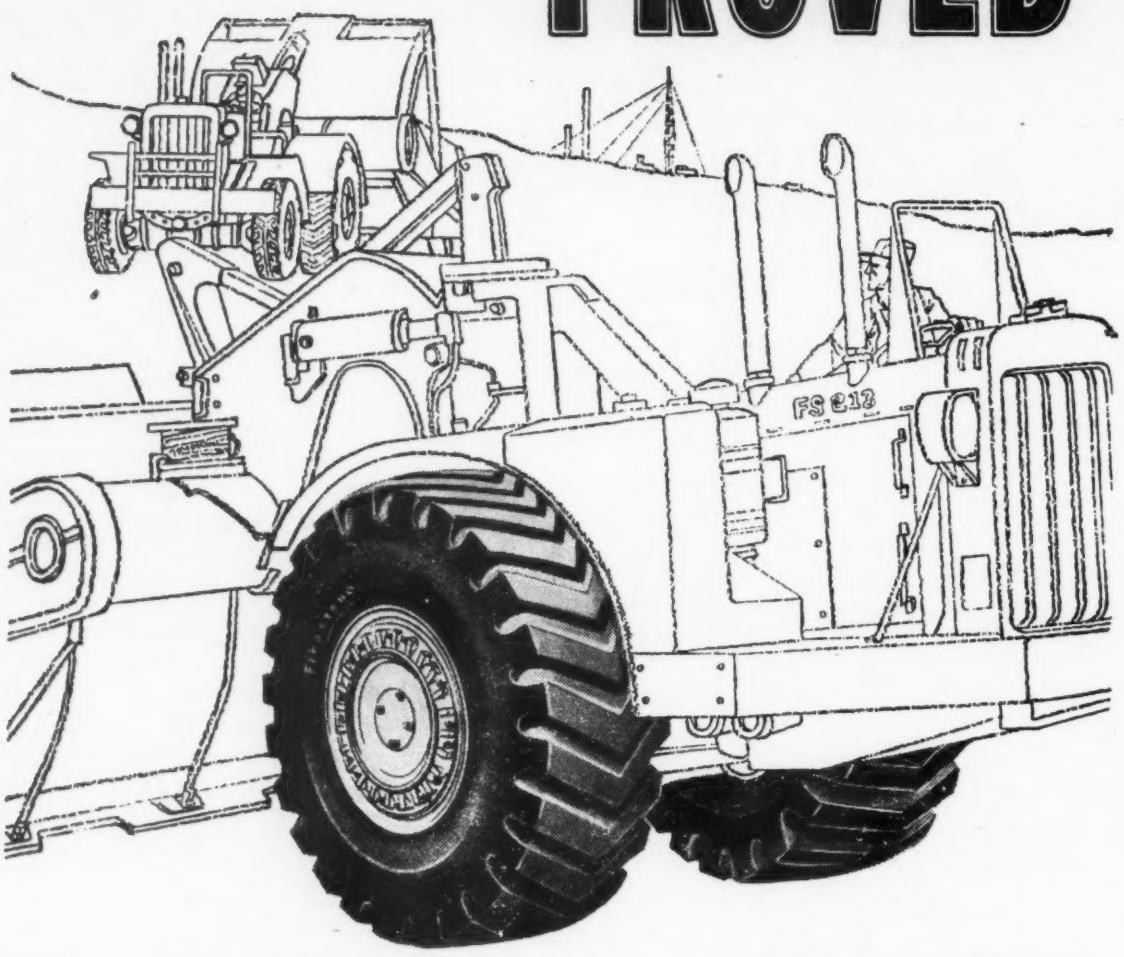

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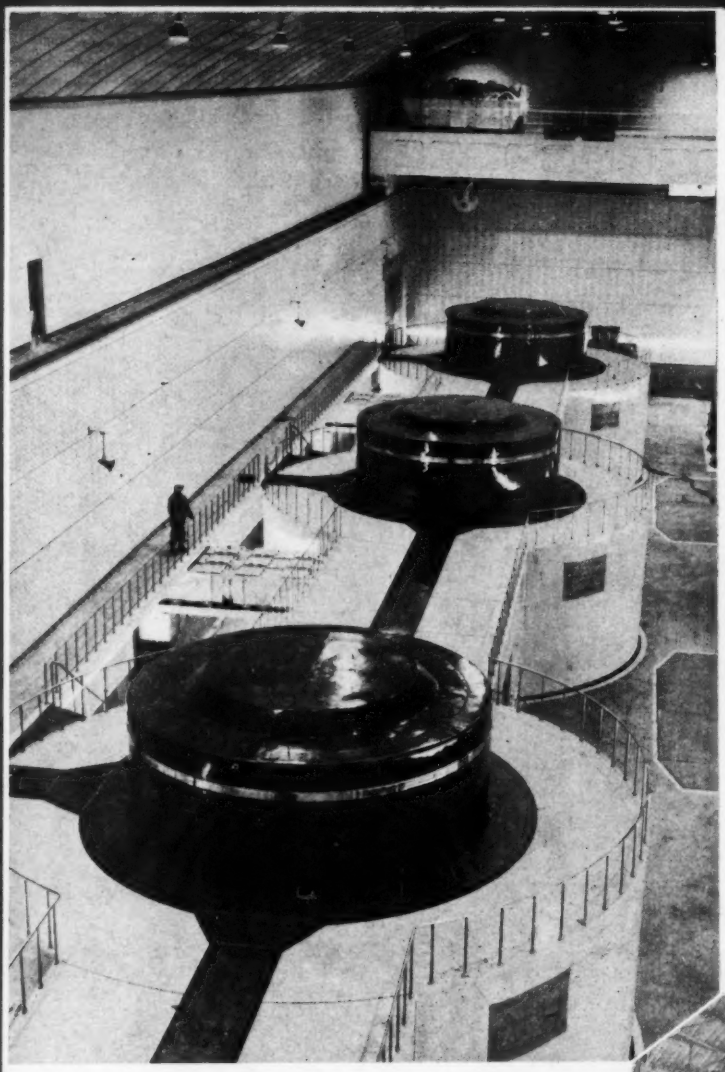

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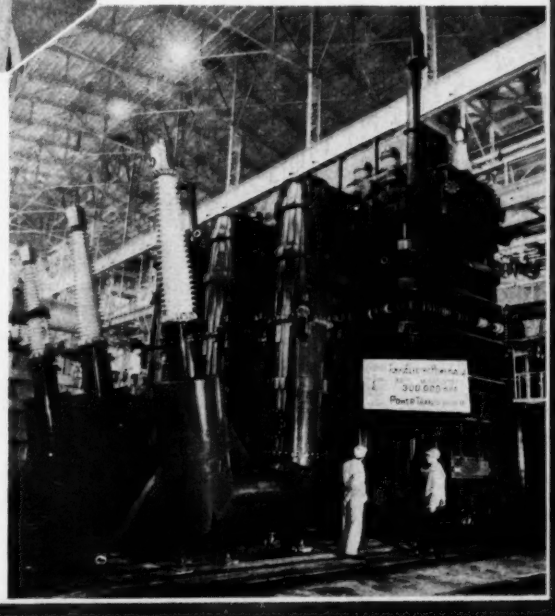

The set of three generators above—each generating 133,000 kVA—is the second largest of its type in the world.

It has been installed in Japan's newest power development project, the Okutadami Power Station.

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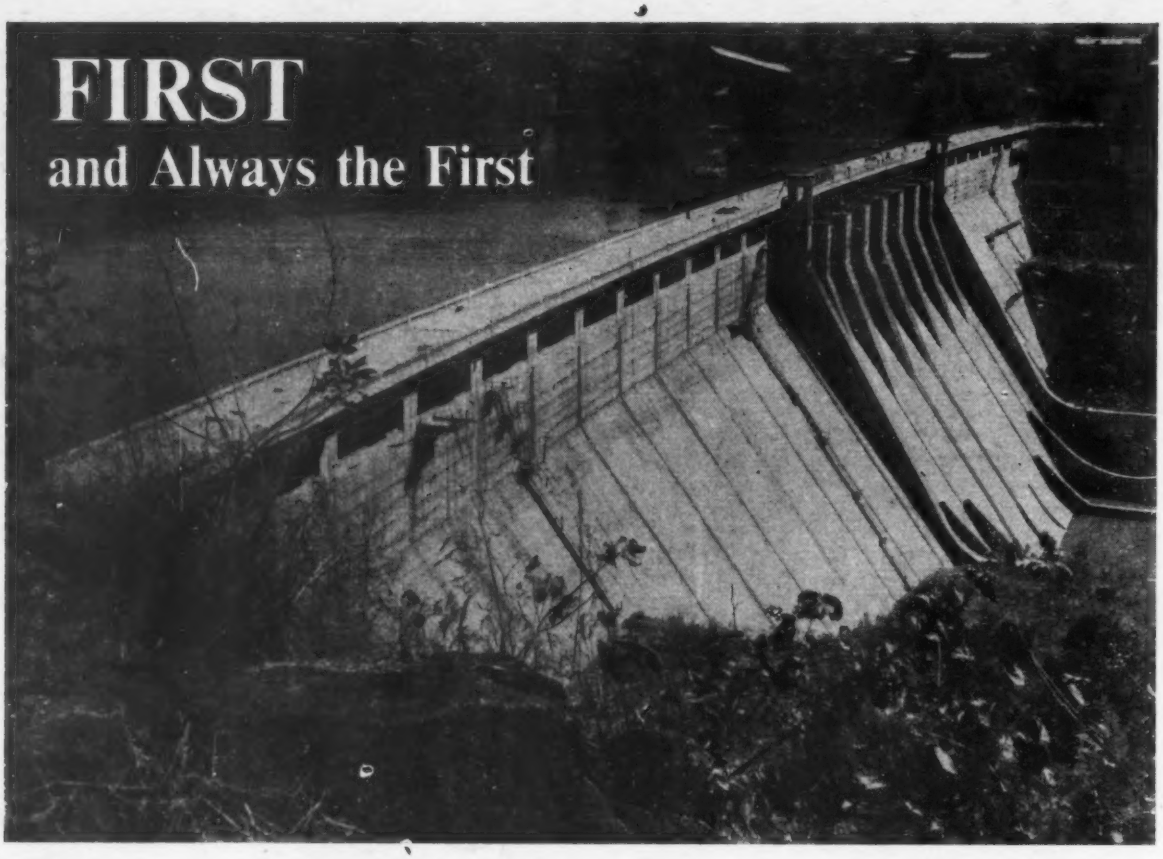

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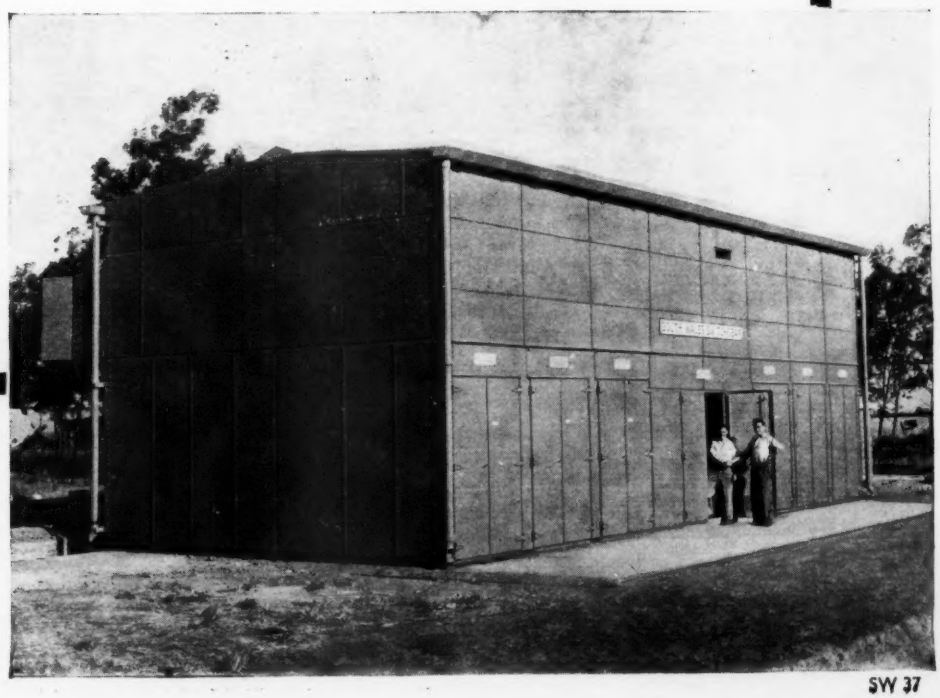

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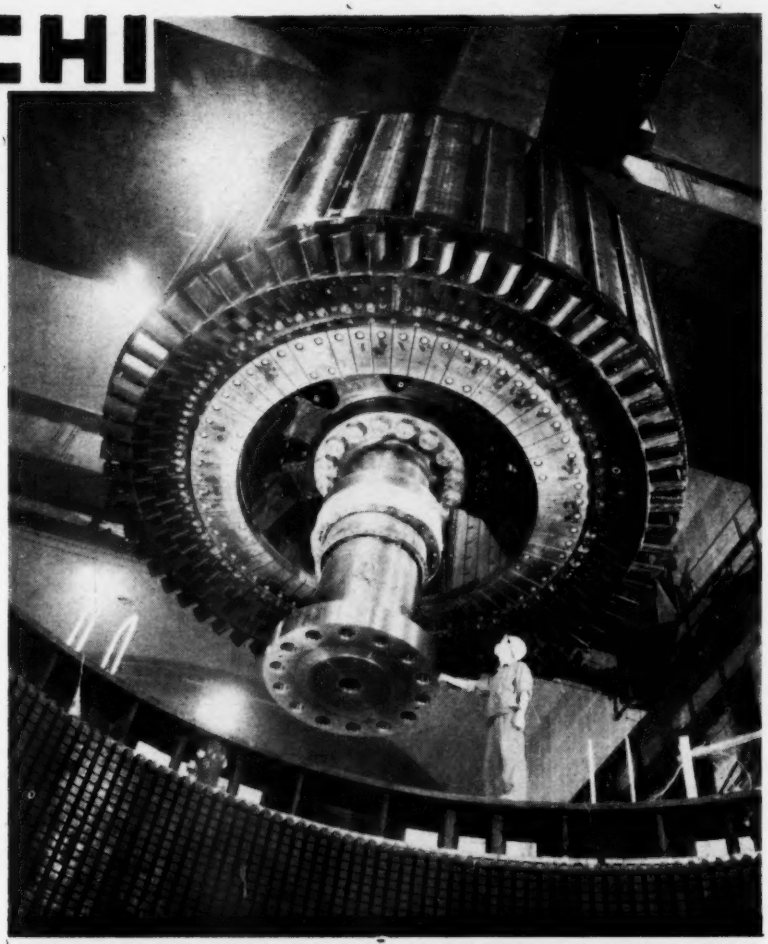

Hitachi has recently completed two 137,500 kw/125,000 kVA hydraulic turbines and generators for the Miboro Power Station in Central Japan. The turbine is of the vertical-shaft Francis type, and specified for a speed of 225 rpm, a maximum effective head of 200 m and 76.6 cu.m/sec water flow, making it one of the largest units of its kind in the world. Its runner has a maximum diameter of 3.7 m and the main shaft a diameter of 95 cm. The spiral casing, which was constructed in 13 sections to facilitate transportation to the site, has an inlet diameter of 3.35 m and an outer diameter of 11.2 m.

The generator presents a high-torsoed appearance, having been so designed in consideration of the comparatively high speed. Since the generator was designed for a rated voltage of 16,500 volts and, in this respect, represents the first such attempt in Japan, particular care was taken in the corona-shielding and impulse resistance of the stator winding. The generator is rated at 60 cycles, 225 rpm and 0.9 power factor but is also capable of operating at 50 cycles, 187.5 rpm and 1.0 power factor.

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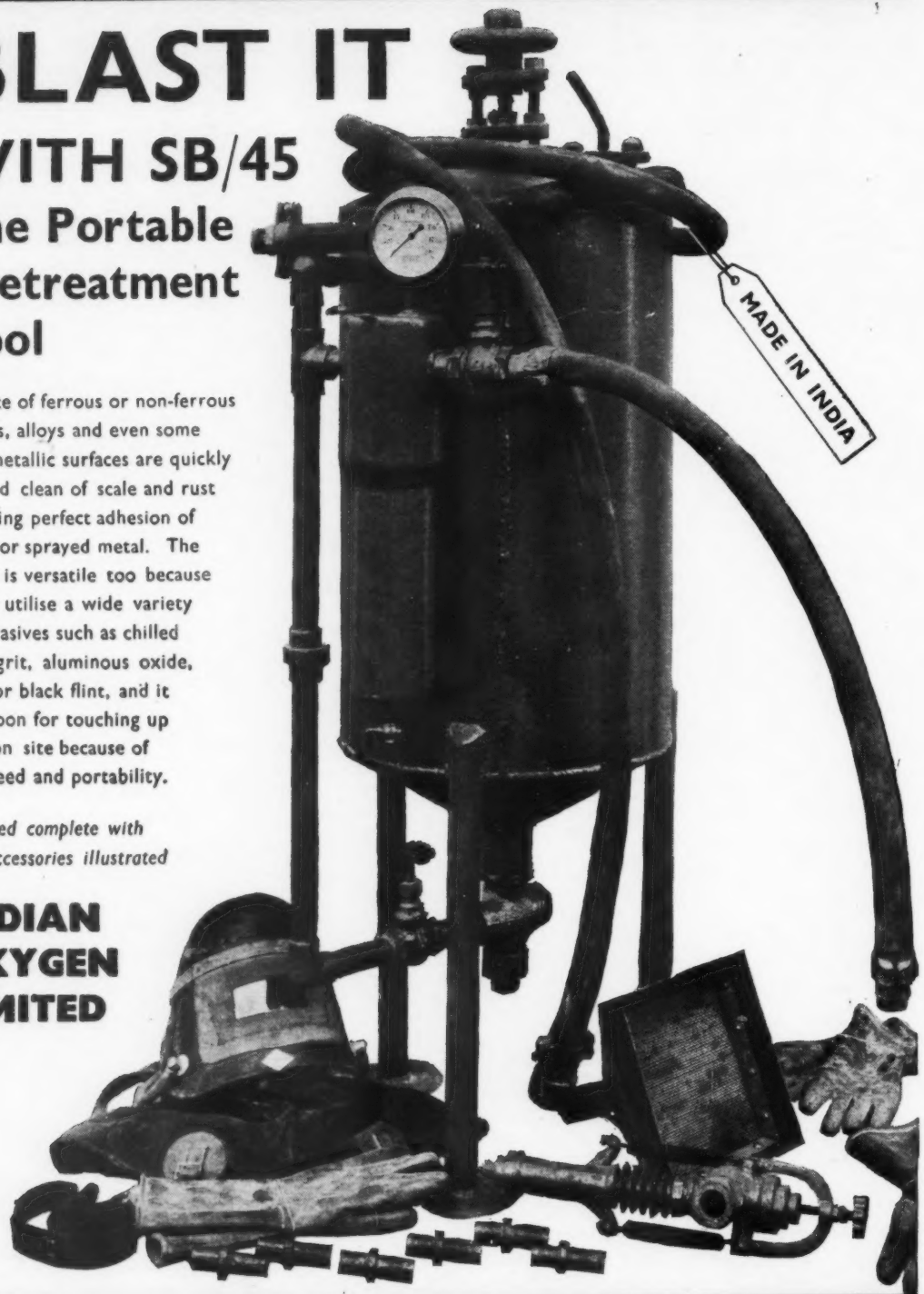

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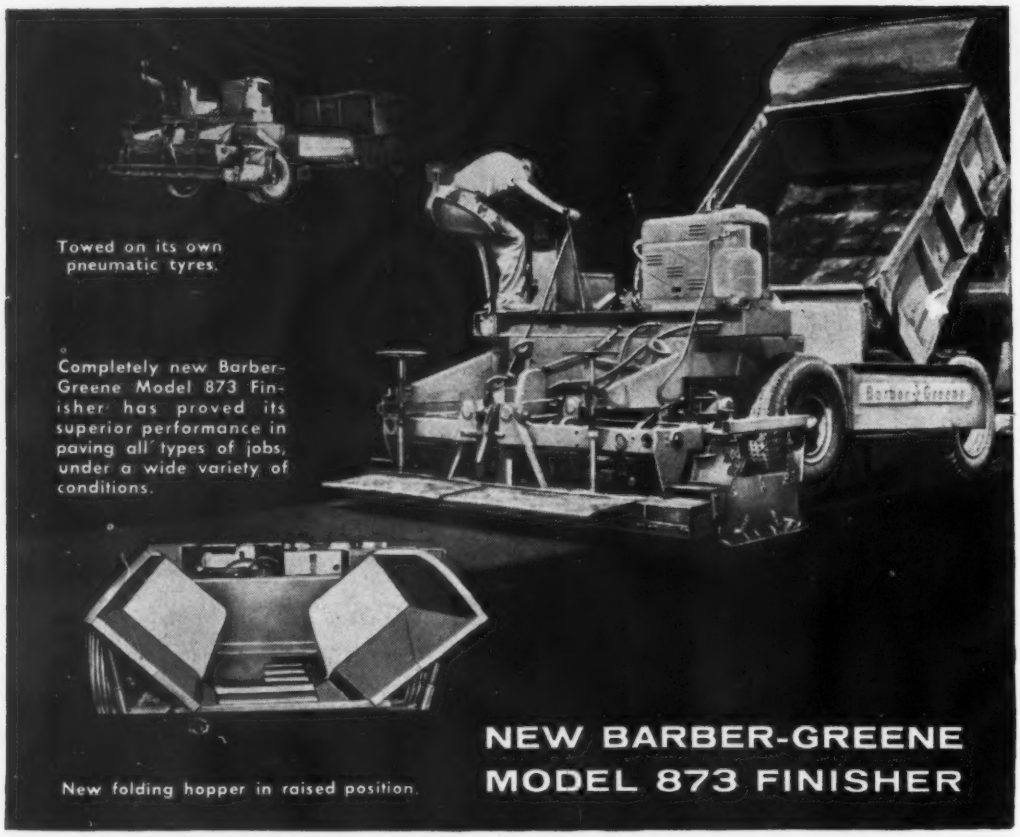
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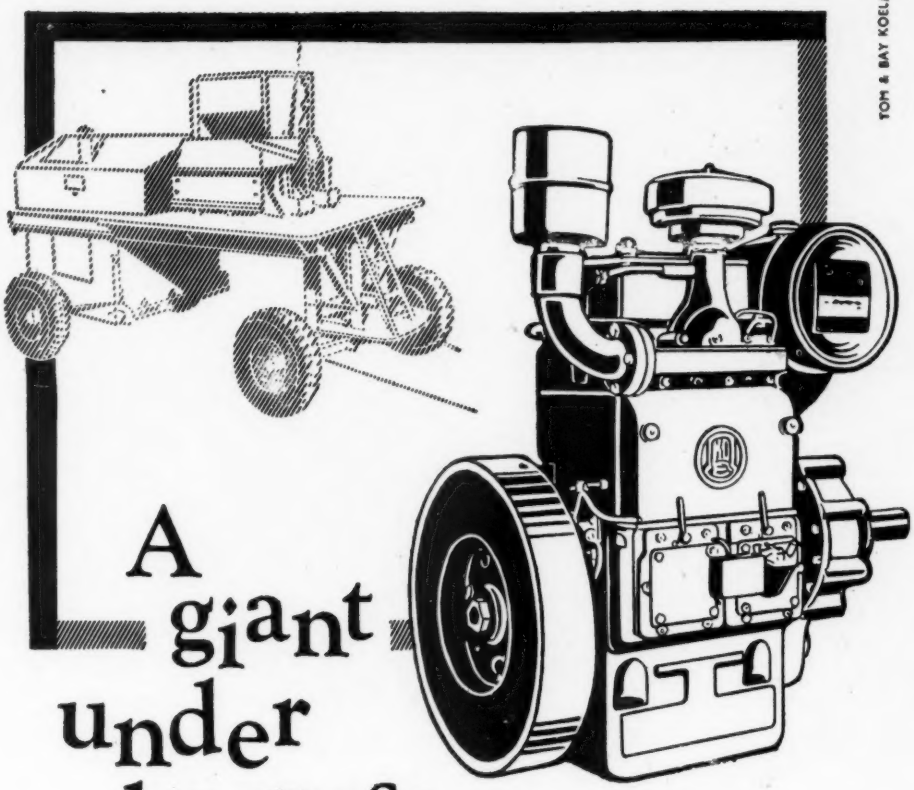

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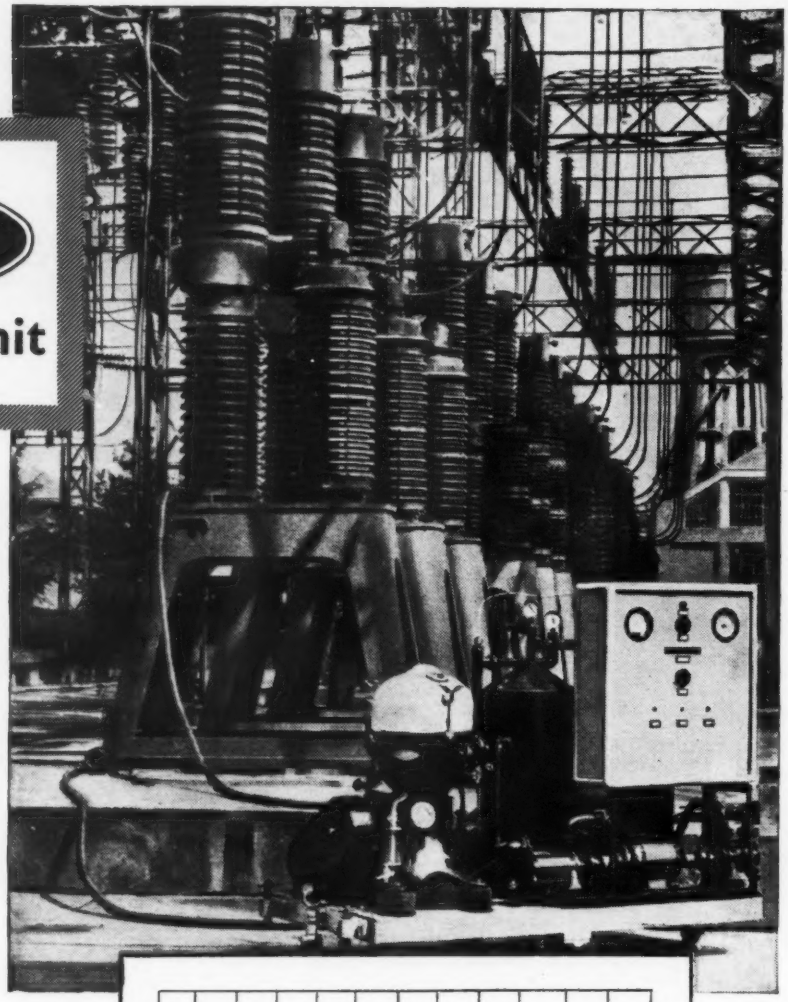

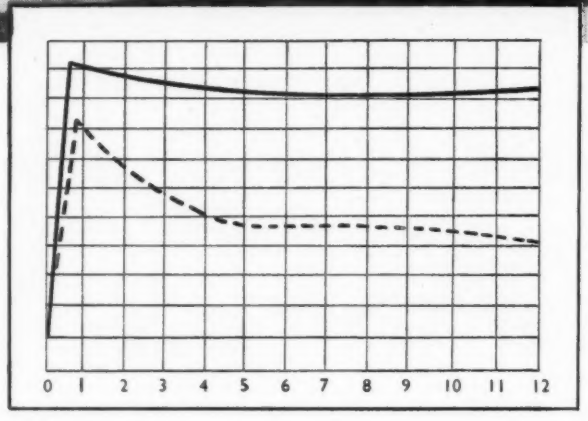

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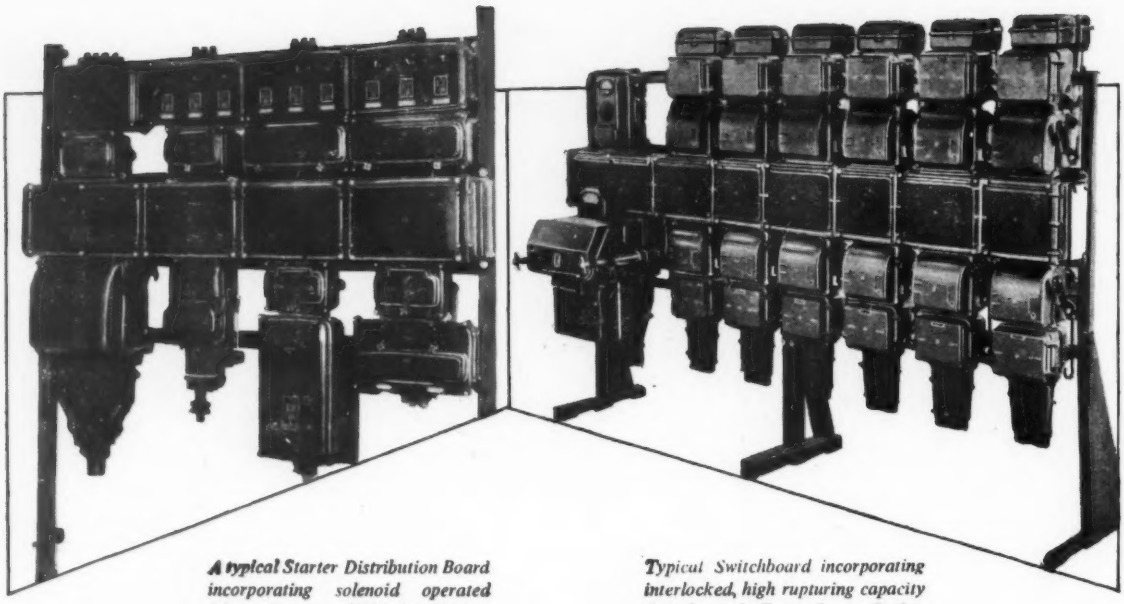

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Editor: K. K. Sinha

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OCTOBER, 1961

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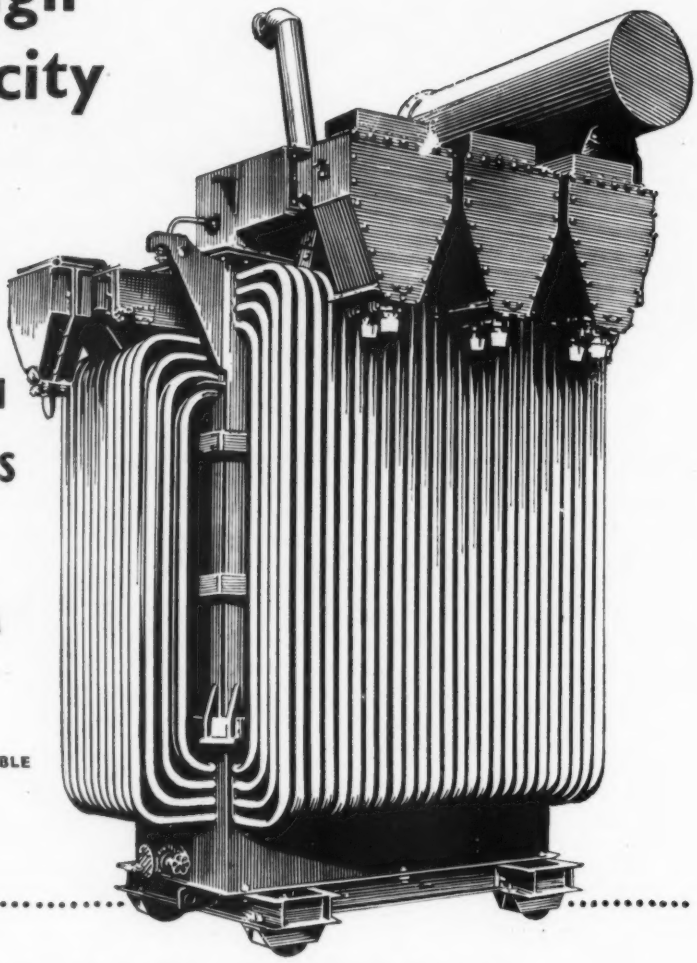

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The Engineer in Commonwealth Development

This Seventh Graham Clark Lecture was delivered at a Joint Meeting of the Institutions of Civil, Mechanical and Electrical Engineers in the Great Hall of the Institution of Civil Engineers, London on April 13, 1961. We are reprinting the Lecture with the kind permission of the Institution of Civil Engineers, London, from the Journal of the Institution of Electrical Engineers, June 1961 issue and we are confident it will be read widely and with great interest.

THE FIRST THING I DID, BEFORE PREPARING THIS lecture, was to look up all the previous Graham Clark Lectures. As it was I accepted your invitation with great diffidence but when I saw who had been my predecessors and what they had said—my heart sank. I realize it is meant as a great compliment, but if you only knew what a lot of hard work I had to do in preparing it I'm sure you would have thought of some other way of paying me a compliment.

Mind you I'm not complaining. This task has proved to be a very important and worthwhile stage in my education so I am most grateful to The Institutions of Civil, Mechanical and Electrical Engineers for inviting me to give this 7th Graham Clark Lecture.

I cannot hope to condense into this one lecture the whole story of engineering in Commonwealth development, but I shall try to get across some of the results of fairly extensive travelling and research. I must confess that I am very bad at statistics so I have tried to avoid them in the text, but those who like them will find that Appendices contain several interesting and, I hope, illuminating tables to do with Commonwealth resources and development.

Some of you may have seen that the original title was 'Resources, human and material, of the Commonwealth'. However, I very soon came to the conclusion that resources are not very interesting until you start doing things to them and that engineers are probably the biggest—if not the most important—group of people who do things to resources. So I changed the name and I have tried to outline the engineer's part in the various fields of development and some of the opportunities and problems of your profession.

I wrote most of this lecture at odd moments during our recent tour of India and Pakistan. Not perhaps an ideal way to set about it, but it did have the advantage that I was able to look at things from the point of view of the relatively less developed countries. You are now about to experience the disadvantages of composing a lecture under these conditions and I can only apologize if you find it a bit disjointed.

I am going to take it for granted that it is generally accepted that development in the broadest sense is a good thing. I hope I can assume that mankind is better off with proper food, sanitation, housing and all the material comforts which modern science, engineering and industry can provide. I am not assuming, however, that this material development necessarily implies a higher standard of human civilization. This, I believe, depends upon qualities of the mind and spirit which are not directly related to material comfort and convenience.

Given the need for development in the material sense it does not take a great stretch of the imagination to visualize the engineer's part in the process. There are, in particular, four ways in which the engineer can implement and influence development :

1. By continually finding practical ways and means of applying scientific principles and discoveries in power, industry, transportation, communication and construction. This means that research establishments are needed in all the divisions of engineering so that practising engineers can apply the benefits of fundamental scientific research.

2. By the application of the latest and most efficient methods to individual projects. This means that practising engineers must have some way of keeping up to date.

3. By the careful administration, maintenance and improvement of the engineering complex. Building or developing some project from scratch may have a great many difficulties, but maintaining and improving a project which has been in existence for

many years calls for even more skill and administrative ability. Railways are an obvious example.

4. By the technical training and education of the next generation of engineers. This is very much the engineer's responsibility and whatever the rewards of practice may be, nothing is more worth while in the long run than teaching the next generation.

The engineer is in fact the means by which the people are able to enjoy the fruits of science, whether in building new projects, or in maintaining and keeping up to date what is already in existence. I need hardly list the highly developed communities of history which decayed for the lack of engineers to keep their great works in operation.

Simple technical know-how is also not enough. In order to make a really worthwhile contribution the engineer needs the vision to appreciate what is possible as well as the technique to realize his dream.

It is also wrong to assume that the engineer is simply concerned with material gadgetry or the purely practical and commercial side of life. All large-scale projects and modernization plans are bound to have a profound and lasting influence upon the lives of very great numbers of people. Unless their conception, execution and running are all based upon a practical humanity they will contribute very little to man's progress.

That is why technological training must be combined with broad general education. Each generation must learn that technical knowledge without a sense of mission and responsibility is wasted. Education which merely produces a sense of dissatisfaction and frustration and a kind of topsyturvy snobbery about what is suitable and unsuitable employment is a failure. The system must instil a sense of the value of engineering to human development so that people come to look upon it with the same sense of service as missionaries and doctors.

At the root of all development are the nations' natural resources; they are the raw materials with which engineers have to work in order to fill the basic needs of the peoples of the world. Food depends on agriculture and increased agriculral productivity depends on agricultural machinery, irrigation, food processing and transport. Industry depends upon power and upon the extraction and transport of its raw materials. Industrial processing itself depends upon the engineer as does the invention and design of those gadgets which are intended to help or entertain the public at large. On top of that lies the very important responsibility of teaching the next generation of engineers in such a way that they can progress from past techniques and build on past experience.

The wealth of a nation, and all which that implies, depends in fact upon the efficient organization of its resources both natural and industrial as well as human. In this organization the engineer bears the chief responsibility.

Food and Agriculture

The engineer has two kinds of resources with which to work. There are the renewable resources, by which I mean those which grow or which are renewed by the climate, and non-renewable resources, those which are extracted once and for all.

Luckily in supplying humanity's basic need of adequate food the resources are not only renewable but the area which can grow them, as well as the quantity from a given area, can be substantially increased by modern engineering and scientific methods. This is particularly fortunate because no country can hope to reap the benefits of industrialization without a sufficient and cheap supply of food for both the rural and urban population. Secondly, if the world's food resources had a known limit at this time the tremendous increase in the population of the world would pose an insoluble problem. As it is things are difficult enough. Dr. Norman Wright of the F.A.O. eestimates that the world population will have grown from 3000 million today to 4000 million in 1980 and 6000 million in 2000. On the basis of bringing the average world diet to a reasonable level by 1980 he suggests that we must increase the world's cereal production by 33% and the world's production of milk, meat, eggs and fish by not less than 100%. By the year 2000, which is only 39 years away, the figures are a 100% increase for cereals and 200% for animal products.

Dr. Wright bases these figures on a broad estimate that the food supplies of countries representing 60% of the world's population fall below 2200 caloriep per day of which nearly half are below 2000—a figure which is 800 calories less than that at which British adults and children start to lose weight.

The situation is even worse than it sounds because in most underdeveloped countries there are inadequacies in quality as well as quantity of food, with the result that the people suffer from malnutrition as well as undernutrition. In North America for instance only 25% of the diet is in starchy foods while in Africa it is 66% and in the Far East it rises to 73%.

I promised not to bring in too many statistics, but there are one or two more which I am sure you will find revealing. The Commonwealth fraction of the world land area is 23% and the fraction of the world population is 24%. Even though Britain has the highest population density, 68% of the Commonwealth population is in India and Pakistan. Out of a total Commonwealth population of 682 million no less than 56% are employed in agriculture—5% of Britain's, 12% of Australia's and 71% of India's. The really interesting part of that comparison is that agriculture, forestry and fishing employ 5% and are worth 4% of the gross domestic product in Britain. Australia employs 12% which

produce 17%, whereas in India 71% of the population only produce 47% of the gross domestic product. This shows very clearly that great strides are possible in agricultural productivity.

For these and most of the statistics in the Appendices I am greatly indebted to the Commonwealth Economic Committee and to the Commonwealth High Commissioners' offices in London.

I said just now that for the time being we are also fortunate that the land area for agriculture can be increased. In fact 44% of the Commonwealth land area is either unused, built-on or wasteland. This figure needs to be qualified, however, because one-fifth of the undeveloped land surface is too cold, one-fifth too arid, one-fifth is mountains and one-tenth has no soil. This leaves about 30% as potentially cultivable and gives some idea of the scope for bringing deserts, equatorial forests and tropical grasslands into production, and the tremendous contribution which engineering can make to agriculture.

Four things are needed to stimulate and increase agricultural productivity :

1. Extension of the area under cultivation which generally means the provision of water in dry areas, the removal of water in swampy areas, and the control of pests, diseases and weeds.

2. Increasing the productivity of the soil by applying more nutrients. This is the first impact of industry proper upon agriculture because plants need fixed nitrogen, phosphorus and potassium which have to go through some sort of industrial process before they are usable.

3. Better equipment for use on the land so that together with the increased use of fertilizers the output per acre can be substantially improved. In the industrially developed countries very sophisticated machinery is needed to increase the output per man. In the less developed countries the emphasis should be on improved design of simple instruments. Remember the ground-nut scheme which prompted the remark 'Give us the job and we will finish the tools'.

4. A system of agricultural organization which will make it worth while for the rural population to grow food for sale. This includes the organization of land tenure, proper transport and marketing facilities and a comprehensive advisory service.

It is no use attempting any or all of these things without taking human nature into account. These points may be self-evident to an outsider but you cannot, without much suffering, force human nature to accept a complete change—even for the better—of the basis of its existence overnight. The art in this case is to reconcile the interests of the individual with the interests of the State.

Much progress has already been made and if we learn from the success even more rapid progress is possible in the future.

It is only necessary to look at the tremendously high agricultural productivity of New Zealand to realize what can be done under very favourable conditions. The Gezira cotton scheme in the Sudan is an excellent example of all the points I mentioned, while the huge irrigation schemes in India and Pakistan are both an encouragement and a warning. Warning because the early schemes have given rise to waterlogging and salinity which are taking as many acres out of production as new schemes are bringing in. New methods of irrigation, drainage and tube wells are now beginning to overcome these problems. I visited the Land Reclamation Laboratories in Lahore and gained some idea of the complexity and magnitude of their task. In addition to recovery of previously productive land there are plans to bring a further 9½ million acres in Pakistan into production by irrigation. Even so the race between the growth of population and the provision of additional resources is desperately close.

Even without mechanization or increasing the area under cultivation productivity can be very greatly improved by the application of fertilizer and trace elements where necessary. This operation, however, depends upon the cheap and therefore industrial production of fertilizer which in turn depends upon cheap power. For this purpose the natural-gas fields of Pakistan are most convenient as they supply both the power and the raw material for fertilizer production.

Taking all this into account it is rather sobering to find that the Commonwealth share of the world's food production is not very impressive. Of the basic foods only rice, 24%, barley, 20%, and mutton, 23%, are in proportion to our population. All the others are way below 20% of the world's output. Coarse grains are only 9%, pig-meat is 5% and wheat 14%. This is in spite of the fact that many areas in Commonwealth countries regularly produce two and sometimes three crops per year already.

From what I have said I need hardly emphasize what is expected of engineers for agriculture especially in the less developed countries.

The next stage after food production is food preservation. There are one or two old-established methods of preserving food but generally speaking the whole technique of food preservation is due to modern engineering methods. It has even gained the title of food technology and not even the homely and old-fashioned smoking and curing methods have managed to escape the food engineers.

Food technology is already most important in keeping out undesirable organisms and where there are large city populations. It is going to become even more important in tropical countries which are rapidly developing huge concentrations of population. This whole field of the preservation and distribution of food is wide open to the engineer. Freezing, canning, curing, spray and freeze drying, ionizing radiation and every kind of processing are all engineering problems.

Lastly, I think it is generally recognized that our harvest of food from the sea is still very underdeveloped. Both the methods of extraction and con-

trol could be considerably improved by modern equipment and scientific study.

Energy

Hand in hand with agriculture to supply the world's basic needs is energy. Energy is the very basis of modern civilization. Whichever way you look at it cheap, convenient and abundant power ranks with food as a means to raise standards of living.

The non-renewable sources of energy are coal, oil, and natural gas. The renewable sources are the sun, wind, water, wood, cow-dung and ultimately the breeder reactor in nuclear power. Also for the time being a very large proportion of the energy requirements for transport and agriculture is met by animal power in the shape of horses, oxen, camels, donkeys and elephants.

Distributed power in the form of electricity and gas, and independent power units in the form of internal-combustion engines are essential to high productivity in agriculture, transport and industry, and most convenient for personal use in the home and on the roads.

The point about all this is that there is a close relationship between the amount of energy available per head of the population and the state of material development of a country.

The explanation is obvious. Poker for irrigation pumps and fertilizer factories raises agricultural productivity. Power for transport distributes agricultural products, brings raw materials to industry, distributes industrial products and transforms individual mobility. Power for industry makes it possible to harvest or extract the raw materials with greater efficiency and it is the very life-blood of industrial processing and manufacture.

Here I must again plunge into some figures to give you an outline of the energy situation in the Commonwealth. You will remember that the Commonwealth proportion of the world population is 24% and the Commonwealth covers 23% of the world's land area. Add to this the fact that 20% of the world's land rainfall falls on, and 18% of the 17 great rivers of the world flow through, Commonwealth countries. Finally, and most significantly, the production of energy by the Commonwealth is only 12% of the world's production even though India and probably several others have doubled their output in the last five years.

This figure of 12% has to be reduced to 10% if you leave out the oil produced in Bahrein, Kuwait and Qatar, and it means that Commonwealth countries at present only produce 3.5% of the world's oil and 3% of the natural gas.

You will find the over-all figures for energy production in Commonwealth countries in Appendix 5 as well as *per capita* consumption of commercial fuels in Appendix 6. These latter are the most revealing figures as they vary from 5.2 metric tons of coal equivalent in Canada to 0.6 in Pakistan.

Looked at in this way it is obvious that there is a very real urgency to increase the energy production and distribution in the Commonwealth.

In this field the engineer has almost unlimited scope and the solution of this energy problem demands more than skill and intelligence ; it demands the services of far-sighted engineering administrators to exploit every indigenous source of energy and to plan the most economic form of energy production from other sources.

Australia for instance is very short of water for all purposes. The Snowy River Scheme will do much to meet immediate demands for energy and irrigation, but there are virtually no other sources of hydroelectric energy on the continent. Fortunately she has considerable resources for the production of nuclear energy.

New Zealand, on the other hand, has fairly large reserves of water power, but they happen to be on the South Island whereas the majority of the population is on the North Island. I see that the New Zealand Government are about to call for tenders to lay power cables across the Cook Strait. This immense engineering project is expected to cost about £ 19 million.

Engineers have also made it possilbe to harness the geothermal steam in the North Island to energy production which was otherwise merely a pleasant tourist attraction.

India has great reserves of coal but they happen to be mostly on one side of the subcontinent, while power is badly needed in many distant places which have no alternative sources. Unfortunately the cost of transporting the coal or the electrical energy is prohibitive so that there may be openings here for for nuclear power stations.

In Canada the situation is that 85% of her electricity is provided by hydroelectric stations and she has still only tapped 28% of her resources of water power. I flew over the Hamilton Falls in Northern Quebec not long ago and I'm not surprised that the engineers have cast covetous eyes on so much energy going to waste.

Power is related to industrial productivity, but cheap power can also attract industry. In Ghana I saw the site for the Volta River Dam which will make it possible to exploit the bauxite deposits not far away for conversion into aluminium.

The giant Kariba Dam on the Zambezi will give a tremendous stimulus to primary and secondary industry throughout the Federation of Rhodesia and Nyasaland.

Like Australia, South Africa is also short of water for all purposes, but on the other hand she has vast reserves of easily mined coal. As a result she is to build a plant for the conversion of coal into oil which is expected to meet one-seventh of the Union's present needs.

I have only referred to the large members of the Commonwealth. It is worth remembering that the smaller places have even more urgent problems

without the material or economic resources with which to solve them. The Atlantic and Pacific islands need energy badly but unless they can harness the wind, the sun, or the tides, there is little scope for development.

Industry and Resources

It is becoming increasingly popular to look upon industry merely as a convenient way of giving employment. Industry does undoubtedly give employment, but that is not its basic function. Industry exists for three reasons :

1. It produces those things which are needed by a community to live a reasonably comfortable existence.

2. It also produces those things which though not essential to human existence are very nice to have.

3. It produces things which can be sold to other countries, preferably at an over-all profit.

I think it goes without saying that industry must also produce all those things which are needed by industry at all stages of the industrial process. In the less developed countries the first stage is the extraction of raw materials for use or export, followed by the production of the basic requirements of the manufacturing industries.

Industry has to satisfy the needs of the State as well as the needs and desires of the individual. In fact it is only by maintaining a proper balance between production for home consumption and production for export that a nation can maintain the upward curve of its standards of living. An adverse balance throws it upon the charity of more efficient or fortunate nations while a too favourable balance will merely widen the gap in standards between itself and its less efficient or fortunate neighbours. There can be no doubt that in the long run there is a greater chance of avoiding conflict if the material standards of people throughout the world are reasonably comparable.

It is difficult and probably misleading to try and generalize about the over-all position of industry in the Commonwealth. Having made the proviso I leave you to draw your own conclusions from the Appendices (7-11) which refer to this section. You will notice that in the renewable raw materials—other than food—production varies from 84% of the world's jute to 51% of wool to 11% of cotton and 10% of timber. In mining the Commonwealth produces only 12% of the world's iron ore, but more than its share of many other metallic ores. I have no figures for the manufacturing industries as a whole, but it is significant that the Commonwealth produces only 11% of the world's steel, 15% of the aluminium and 11% of man-made fibres.

If you take this in conjunction with the fact that in only five major Commonwealth countries do the manufacturing industries account for more than 20% of the gross domestic product while at least in six countries agriculture and forestry account for more than 40% of the gross domestic product, as well as the fact that we only produce 12% of the world's energy, the picture comes into rather sharper focus.

The implication is that in agriculture, basic industries and energy the Commonwealth output is not in proportion to its area or population.

I have already dealt with the energy picture and with certain exceptions there seems to be no reason why the Commonwealth as a whole should not produce its proper share of energy, but nuclear power will be necessary to achieve this in many areas.

Much the same applies to agriculture, but there the picture is rather distorted by the Indian subcontinent and Africa where at the moment there is a very high proportion of subsistence farming.

In mining the possibilities are very difficult to assess, but it would seem that we have hardly begun to tap the known mineral resources of Canada and Australia, while in India and Africa even the survey has not been properly completed. Some figures for Commonwealth mineral resources are contained in Appendix 11 which show that there is much to be developed.

The expansion of the manufacturing industries is a very complicated business which is really outside the scope of this lecture, although engineers are very closely concerned in it.

The total resources of the Commonwealth are probably roughly in proportion to its size, but this does not mean that the resources are evenly distributed. Each country has certain limiting factors and may lack certain raw materials, but on the other hand most countries have probably got something which is needed or wanted by others. There is no absolute need for countries to be self-sufficient ; the real need is for Commonwealth countries to co-operate in such a way that the people can enjoy a reasonable standard of existence and the chance to develop their talents and their resources for the common good.

This means that methods of extraction, methods of refining, methods of processing and the transport system are the factors which can turn deposits of natural resources into wealth-producing assets. Where these are lacking, and this is by and large the situation in Britain, the only solution is the highest development of the human resources by a very advanced system of education and training. All these are problems for the engineer and the success with which they are tackled by imaginative engineers can transform the whole picture of industrial and economic activity in Commonwealth countries.

Transport and Communications

Having outlined the contribution which engineers can make to the development of agriculture, energy and industry in the Commonwealth, I must quickly add that none of their efforts would bear any fruit without an adequate system of transport and communications. It is virtually impossible to develop natural resources, or improve and augment the food situation, or even to enjoy the benefits of industrial

enterprise without a comprehensive network of public and commercial transport and communications.

Indeed transport and communications are the means whereby the whole porcess of development is given purpose and direction and the only way by which the people can begin to adapt themselves to changing circumstances.

A community which is without the proper means of movement and contact is cut off from the world and therefore can only exist upon its own—usually very limited—resources. It cannot co-operate with its neighbours and its intellectual level is also bound to be restricted. As communications develop so its limit of experience is increased until it reaches the point where it is connected by the fastest transport and a virtually instantaneous communication system to all the other developed and mutually interdependent communities in the world.

Roads and paths made it possible for villages to co-operate, railways made it possible for districts to work together, while ships and aircraft have brought whole continents into contact for trade and commerce.

In the same way telegraphs and telephones, radio and newspapers are removing the barriers of ignorance and bringing the nations into closer concern with each other's problems.

Trade brought the old Empire into existence and communications kept it together. Now that it has become a Commonwealth of nations, transport and communications are making it possible to co-operate in every field of endeavour to the mutual advantage of all members.

A measure of the importance we attach to transport and communications in Britain is the amount of time and space devoted to its discussion. Anyone can start an argument any time by just mentioning British railways or British roads. And yet it is only 602 miles from Land's End direct to John o' Groat's and that's as far as you can go in these islands overland. If the Shetlands are included it makes a total of 768 miles. Compare this with Halifax to Vancouver, 2850 miles, Perth to Sydney, 2030 miles, Lagos to Kano, 518 miles, or Calcutta to Bombay, 1225 miles. To cover areas of this size with a network of roads and railways is a staggering task and yet it must be done if development is to take place. I think it is most significant that Canada has recently launched a programme of 'Roads to resources' so that the mineral wealth of the Northern wastelands can be exploited.

I sometimes wonder whether our transport engineers are fully aware of this enormous difference in scale between the problems of transport and communications in these islands compared to the larger Commonwealth countries.

There are similar difficulties in air transport. The distances, geography and climate in Britain are so different from other Commonwealth countries that it is not altogether surprising that there is an entirely different attitude to flying.

In Ausralia, India, Africa and Canada flying conditions, though uncomfortable at times and impossible for short periods, are such that aircraft can be operated for all purposes almost all the year round. As it is, the internal—or outback—flying in those countries is not unlike a country bus service. It certainly couldn't be more different from the sophisticated international air passenger systems which use the London airports.

This difference between British conditions and conditions in other Commonwealth countries also applies to aviation for agricultural purposes. Although there is a certain amount of agricultural aviation in Britain it is nothing at all compared to the potential employment of aircraft for this purpose in most Commonwealth countries.

The British aircraft industry is the most highly developed in the Commonwealth for the time being, but it cannot hope to continue to play a major part in the development of the Commonwealth unless it has the services of imaginative engineers who understand the needs and the conditions of the other Commonwealth countries.

We have certainly not reached the end in the development of transport systems. Aircraft capable of vertical take-off and landing, blind-landing systems, monorails, flat electromagnetic traction and air-cushion craft are all waiting to be converted into economic possibilities by engineers.

The Hovercraft type of vehicle in particular may easily revolutionize overland transport in the more remote regions of many Commonweatlh countries. Its major advantage as I see it is that there is no need for expensive ground installations such as roads or railway lines. So long as the track is reasonably level and the gradients not too severe these craft ought to be able to operate over almost all kinds of country. In Canada, for instance, summer transport in the north is by barge up rivers and lakes. During the winter it is by caterpillar-drawn sled-trains. The Hovercraft ought to be able to operate equally easily summer and winter over snow and ice or water and land.

If this sort of craft has a reasonable operating economy there would seem to be openings for it in the outback of Australia, in Africa and in parts of India and Pakistan. In Bengal roads and railways have to be raised to keep them clear of flooding, and if they are to cross the Ganges delta or serve the islands in it, the bridge-building programme alone would be extremely expensive. Under these circumstances an amphibious vehicle riding on an air-cushion might have considerable advantages.

Just after I had written that piece on the way from West to East Pakistan I came across a leading article in one of the Calcutta papers entitled 'Bengal air-cushions'. Amongst other things it asked 'Is it possible to receive some of the silted-up river channels as busy arteries of trade by use of that remarkable post-war development the Hovercraft ?—if this type of craft proves economical . . . it may make some dying rivers useful again'.

In sea transport conditions are of course much the same all over the world. From the engineers's point of view therefore the two most fruitful fields of activity are in the pocesss of shipbuilding and in the facilities for cargo-handling both on ships and ashore. Although it looks as if economics are against nuclear-powered merchant ships for the time being, it would be wrong to neglect their possibilities.

It seems a pity that the D.S.I.R. report on the ship-building industry in Britain should have caused so much trouble. A little mild and well intentioned criticism, even if its accuracy is disputed, should be treated as a signpost rather than as a slander. I admit it may be easier for me to take this attitude as I have to bear criticism rather more frequently than most.

Distance, geography and weather do make quite such a difference to communications although here again the pattern of Press, radio and television development in Britain is governed by distance. Commonwealth countries have their own particular problems, but the need for posts and telegraphs, telephones, radio, Press and television is just as great in those countries and their development and installation is another of the engineer's tasks and responsibilities.

Scientific Research

All progress in engineering ultimately depends on scientific research and there are two aspects of scientific research as far as the engineer is concerned. First there is the fundamental and applied research which provides the engineer with new materials and techniques and with new applications of known principles. Secondly, there are the huge research instruments which have to be designed and built by engineers to enable the scientist to continue his investigations.

Many of the great strides in engineering history were made before scientific research was used deliberately to find new techniques. In recent times, however, we have come to think of science as producing the new ideas and engineering as the means of exploiting them. So much so that we are inclined to forget that much scientific research is only possible with the aid of very advanced engineering. Computers, electron microscopes, accelerators, radio telescopes and satellites are no longer bits of apparatus that can be knocked up in the lab. All these instruments and many others are the products of a highly sophisticated engineering industry.

As the developing countries begin to establish their own basic and applied research organisations and their own centres of advanced teaching, these complicated instruments will be in great demand and it is reasonable to suppose that they will get more rather than less complicated in the future.

It can well be argued that the developing countries should not spend their time on basic research until they have established a comprehensive applied industrial research organization.

From a practical point of view this is probably quite right, but on the other hand it would be a mistake to deny those people who are both capable and determined to do basic research the means to do their work in their own country. One or two nationally and internationally known figures in advanced science or engineering can do a very great deal by their example to enhance the reputation of science and engineering in the eyes of their fellow-countrymen and abroad. Dr. Siddiqui's recent election to the Royal Society is a good example. He is the Director of the Pakistan Council of Scientific and Industrial Research. There are, of course, many other Fellows of the Royal Society from Commonwealth countries.

Applied scientific and industrial research is, of course, essential in every country, if only because the conditions and the industrial activities vary in each country. Most of the Commonwealth countries have an organization similar to the British Department of Scientific and Industrial Research and although this Department is helping other countries in the development of roads and housing in the tropics, it would be a mistake to expect these organizations to investigate problems which only affect the economy of some other country.

Education and Training

If it's easy to start an argument about transport, it is just as easy to start a riot about education and training. But on this occasion I don't want to start an argument or a riot; I only want to draw your attention to some of the problems and difficulties facing engineering training and education in the Commonwealth.

One of the problems of engineering education is that it covers such a wide field. It includes science to manual skill and everything in between. It can be subdivided into a number of specializations and yet none of them are any use by themselves and all must have a proper appreciation of the part which engineering as a whole plays in the organization of modern life and in future development.

In Appendix 14 you will find some figures which are intended as a basis for comparison. These figures show the comparison between Commonwealth countries and they make it look as if the United Kingdom is reasonably well off. This is very far from the truth. To get an accurate picture of the position in Britain I recommend a comparison with our industrial competitors in Europe. For instance Unesco estimates that the number of University students per million of the population in Britain is the lowest in Europe. No other country expects its students to graduate in three years.

Even plans for the future are not very encouraging. Sir Geoffrey Crowther has estimated that by the early seventies only about 4% (6% men, 2% women) of the children who are now just beginning their education will be able to carry it as far as a first or bachelor's degree. If the birth-rate continues to go up this proportion will of course go down unless more places are provided. He goes on to say

'Looking forward as best we can to the society of the 21st century, to its economy and above all to its technology, can we conceive that it will be adequately run by a generation of whom only 1 in 25 will have reached even a first degree? Is not this, in fact, a formula for national decline?' In all fairness I must add that Sir Geoffrey Crowther has not taken into account other forms of higher education such as Teacher Training, Colleges of Advanced Technology and Technical Colleges, nor all the students who will soon be taking the Dip. Tech., many of whom will be engineers.

Dr. Bowden of the Manchester College of Technology recently drew attention to another aspect of this problem. 'A recent satistical survey', he wrote, 'has shown that the British economy is expanding more slowly that that of most other European countries. On the assumption that the gross national product per head was 100 in 1950, West Germany has now reached 171, the O.E.E.C. countries average 139 and the United Kingdom only 122; and this despite the fact that the proportional rate of investment per workers in this country has been quite high during the last decade. It is clear that our investment has not been as productive as it should have been; I believe this may well be due to the inadequacies of our educational system.'

After that rather gloomy piece I must quickly add that in January of this year the Government produced a White Paper on 'Better opportunities in technical education' which sets out the proposed reconstruction of the system of courses for technicians, craftsmen and operatives in the Technical Colleges of England and Wales. These have still to be implemented but there seems to be every reason to hope that they will have a profound effect upon the whole pattern of technical education. At least they recognize that no new idea from a scientist or designer can become an efficient piece of equipment without the particular skill and ingenuity of technicians, craftsmen and operatives.

It only remains now for these plans to be matched in that unhappily large section of industry which still does not provide sufficient effective training for its young recruits.

It was with this situation in mind that the City and Guilds of London Institute agreed, at my suggestion, to run a Commonwealth Technical Training Week at the end of May and the beginning of June this year. There has been a most encouraging response from all Commonwealth countries and we hope very much that the Week's activities will attract the attention of young people, their parents and employers to the need for technically trained people and to the ways and means of getting that training.

This problem of higher education and technical training cannot be solved once and for all. Every country in the Commonwealth should look forward to progressive development which means that plans for education must look ahead to the needs of the next generation. Nigeria, for instance, has just published the Report of the Ashby Commission on Post-School-Certificate and Higher Education. This makes very interesting reading and shows what a tremendous problem they have to contend with.

There are at present 1800 students at Universities in Nigeria and a further 1000 in Universities overseas. The Commission estimates that only 900 students graduate from all Universities in one year whereas the need over the next ten years is for at least 2000 graduates a year. This means a University population of about 10000.

Three out of every four Nigerians work on the land; 17 shillings in every pound earned from Nigerian exports come from agricultural products, and yet only 20 men graduate in agriculture every year. The estimated need is 200 and 300 intermediate trained agricultural and veterinary officers.

This is only an estimate for the next ten years, but as soon as the impact of industrialization makes itself felt the demand for educated and technically trained people of all kinds will increase rapidly and progressively.

It is quite useless for the more fortunate countries to offer their help in building dams, power stations and factories if the managers and engineers needed to operate them are not available. Furthermore it doesn't take very long to put up the physical structures, but it may take anything up to 15 years for the people to gain sufficient knowledge and experience to run them.

If the various aid programmes, such as the Colombo Plan, are to be any lasting value, there must be a strong emphasis on technical education. Colleges, equipment and teachers are all badly needed, and teachers in particular will be needed for a great many years to come. This means that those countries with well-established higher technical educational facilities must take this added responsibility into consideration. Providing places for other Commonwealth citizens is only a temporary emergency solution; in the long run engineers and technicians must have their basic training in their own countries.

Dominating this whole worrying problem is the constant increase in population. India, for instance, plans to increase educational facilities by 5% per year and this means a very substantial increase in the bill each year. However, the population is increasing by about 2% per year so that the actual rate of increase in educational facilities is only just about 3% per year. This is a country where on the average only about 55% of the children of primary-school age go to school at all.

The British Government and British industry have agreed to establish and help to run a College of Technology in Delhi. I laid the foundation-stone two years ago and when it is completed it will be a most valuable contribution to engineering education in India, but it all depends on whether Britain can provide the equipment and enough qualified professors. India has such an enormous expansion pro-

gramme for technical education that our most effective help lies in providing teachers and in teaching those who are going to be teachers.

The significance of all this to engineers is that you cannot expect development and progress to be maintained unless you make sure that there are enough people in the next generation capable of carrying on your work. Only engineers themselves are capable of estimating what a nation's future needs are likely to be in graduates and technicians. Only engineers can decide what the qualifications should be in the light of the current state of engineering development. Only engineers who have themselves been properly educated can begin to impart the necessary knowledge into the next generation. It is not simply a matter of maintaining standards of knowledge and conduct; it means that you are ultimately responsible for the material well-being of your fellow-citizens.

Professional Organization

In our system, and it also applies to several other Commonwealth countries, most professions are self-governing with very considerable powers over their members. Entrance is controlled by examination, professional ethics and practice are carefully watched and the whole tone of the profession is set by the professional organization.

I am in no position, least of all today, to judge whether the professional organization adopted by engineers in Britain is the most suitable one to enable you to fulfil your responsibilities. Equally I have no intention, for obvious reasons, of suggesting what the organization should be.

In a profession such as engineering, which covers such an immense field of activities, there are bound to be an increasing number of specializations. Even so I believe that all the specialists would agree that there is a general background common to them all. The thing to remember is that in education we all start off equally ignorant and only gradually build up a specialist knowledge. Then as administrative duties increase and your specialist knowledge tends to get a bit out of date, the importance of your own specialization gradually gets less and your appreciation of other specializations tends to grow, particularly when you ultimately find yourself successfully administering a complex of different kinds of engineering.

Any large engineering project must depend for its planning and successful completion on the closest possible co-operation and integration of many specialists. When it comes to exporting engineering the tendency is for Governments to commission a complete project —or package deal—from another Government or from a group or consortium of companies. The Durgapur (British), Rourkela (West German) and Bhilai (Russian) steelworks in India are examples of this and I should be very surprised if any of the engineering specializations were not involved in some degree in their construction. The interesting thing about these projects is that owing to the fact that there is such a close relationship between all aspects of engineering in Britain and India, the number of foreign experts necessary to build and equip these steelworks was considerably smaller at Durgapur than either of the other two.

Clearly the contribution which engineers can make to the development of the Commonwealth depends to a large extent upon the organization of the engineering profession both nationally and inter-Commonwealth.

I am delighted to know that the engineering institutions in Britain have been getting closer together in recent years with highly satisfactory results. The three host Institutions today have also taken the lead in bringing the sister bodies of the Commonwealth into closer touch. They organized the first Commonwealth Engineering Conference in 1946 and these have taken place every four years since then. Much has been achieved by these Conferences and by other means, and I hope this movement will grow and gather momentum so that the engineers of the Commonwealth can take full advantage of the relative freedom of movement and common language in the Commonwealth to practise or gain experience or to offer to collaborate freely with their Commonwealth colleagues. There is so much work to be done.

By the nature of things each Commonwealth country is bound to develop certain engineering specialities. For instance Canada has already gained considerable experience in hydroelectric work, India and Pakistan are deeply involved in irrigation problems, New Zealand is very advanced in dairy technology, and I expect there are some things of which Britain has a particular knowledge. If the Commonwealth is to make the most of these varied talents it is essential that the professional institutions should make determined and continuous efforts to keep in close contact with each other.

Conclusion

Different people may expect different things from engineers. I have suggested that they are necessary to meet humanity's basic needs of food and power, to develop and at the same time to conserve natural resources, to exploit the advantages of the industrial process and to enable science to continue its investigations. Their original thought and technical management are the main factors in a nation's prosperity. In fact while doctors are responsible for the bodily welfare of people, the engineer is responsible for the bodily welfare of people, the engineer is responsible for the material welfare of nations. This is a very wide responsibility, but unless it is recognized by all the organizations which have the duty of educating engineers they will fail to turn out people capable of giving direction and purpose to the progress of the world.

In this lecture I have tried to show that the engineer is the key figure in the material progress of

the world. This is particularly important at this moment in history when we are beginning to realize the dangers in a situation where some countries are enjoying all the fruits of material progress and others none at all. There is a growing feeling that this unbalance is neither morally acceptable nor is it likely to improve the chances of peaceful conditions.

It is obviously impossible for the more fortunate countries to stop and simply wait for the others to catch up, and it is equally impossible for the others to catch up unaided. The gap in material standards can only be reduced by a real co-operative effort and since material development depends so much upon engineers, that co-operative effort means a co-operative effort by engineers.

The first necessity is an effective administrative frame-work so that the co-operation and collaboration between engineers of the world can take place. Take, for instance, engineering and technical training. There is said to be a shortage of engineers in the developed countries; there is no doubt about the shortage in the less developed countries. There is also a shortage of engineering teachers, and they are even more important because teaching does not only depend upon the number of teachers, it depends very much upon the moral and cultural example which they set. We cannot expect the direction or the momentum of development to be maintained without an adequate number of suitable engineers and technicians and the means of educating and training them.

I keep harping on the need for engineers to be educated as well as trained because I don't believe that specialist training necessarily affects those characteristics of the mind which are needed for human administration. The qualities of imagination, enthusiasm and compassion are present to a greater or lesser extent in all of us, but it needs the process of a general and liberal education to give them point and direction. Specialist training can give people the ability to make sweeping technological innovations, but it needs a broad and liberal education to enable people to foresee the effects of those innovations and to recognize how to introduce the fruits of modern science and engineering to the best advantage of the people.

That is the main task for the engineer in the future and the engineer of the Commonwealth can do this for one-quarter of the world's population. There are immense opportunities for engineers to increase the standards and prosperity of the countries of the Commonwealth, and it also offers every kind of engineering experience for the enterprising.

The target we should set ourselves in the Commonwealth is a reasonable material standard for all its people, and the main responsibility for reaching that target will rest on the engineer.

That, in the end, is the engineer's contribution to Commonwealth development, and it is my hope that the engineers of the Commonwealth with work together to reach that target in a spirit of trust and friendship.

Appendices

Many of the statistics in these Appendices were furnished by the Commonwealth Economic Committee for this express purpose. The Committee point out that, since international statistics necessarily describe many diverse things and activities under common headings, it is essential to use the figures with caution and with attention to the relevant notes. The mineral-resources picture is constantly altering with new discoveries of deposits and with changes in technical and economic conditions: thus the list of Commonwealth mineral resources is no more than a reasonable estimate, in the light of existing surveys and current conditions, of the reserves capable of use in the foreseeable future.

FOOD AND AGRICULTURE

Appendix 1. Commonwealth population: world comparisons 1958.

	Total (thousands)	Density per sq. mile
United Kingdom	51870	551
Canada	17048	4
Australia	9846	3
New Zealand	2282	22
Union of South Africa	14418	31
South-West Africa	539	2
Ghana	4836	53
Federation of Rhodesia and Nyasaland	7780	16
Nigeria	33052	97
Other African territories	28045	25
India	397390	315
Pakistan	85635	235
Ceylon	9388	371
Federation of Malaya	6515	129
West Indies and Caribbean	3929	39
All other Commonwealth territories	9362	23
Commonwealth	681935	57
World total	2852000	55

Commonwealth proportion of world total = 24%
Source : United Nations statistical yearbook, 1959

Appendix 2. Labour force (Economically active population)

	Year	Total (thousands)	Percentage of total in Agriculture	Percentage of total in Manufacturing industries
United Kingdom	1951	22610	5	37
Canada	1960	6234	12	25
Australia	1958	3284	12	32
New Zealand	1956	817	16	24
India	1951	101775	71	9
Pakistan	1954-56	26100	65	11
Ceylon	1957	3508	57	9
Mauritius	1952	165	44	14
Jamaica	1953	615	49	12
Trinidad and Tobago	1956	267	25	17
Fiji	1956	93	57	6

Source : Yearbook of labour statistics 1960, except for Australia and Ceylon which are from national sources.

Note : The figures above are only very broadly comparable, one of the main difficulties being the number of underemployed or part-time workers in agriculture.

Appendix 4. Estimates of the value of exports of agricultural products as a percentage of the gross value of agricultural production (including animal husbandry), 1958

United Kingdom	7
Canada	32
Australia	55
New Zealand	70
Union of South Africa	40
India	4
Ceylon	60

Note : Production : Estimates of gross values of agricultural production (including animal husbandry) have been been made from national sources. Definition are only broadly comparable owing to differing methods of valuation etc.

Exports : (valued f.o.b.) include canned and dried meat, milk and fruits, dairy products, milled cereals, fined sugar, wine, fruit juices and vegetable oils, but exclude manufactured foods such as biscuits and confectionery, cigarettes, spirits and beer, processed raw materials such as wool tops and jute manufactures.

Appendix 3. Land area of the Commonwealth : world comparison (figures relate to latest available year or period) (million acres)

	Total area	Land area*	Agricultural area: Arable and free crops	Agricultural area: Pastures and meadows	Agricultural area: Forested land	Other land: Unused but potentially productive	Other land: Built-on, wasteland, etc.
United Kingdom	60.5	59.7	17.6	30.4	4.1	—	8.4
Canada	2464.7	2271.9	100.3	54.1	845.0	179.7	1285.6
Australia	1903.7	1903.7	61.2	1081.6	98.5	--	662.5
New Zealand	66.4	65.7	1.2	31.2	23.0	1.2	9.8
Union of South Africa	302.2	285.4	27.0	213.6	2.4	—	59.3
South-West Africa	203.6	203.1	0.4	126.1	12.4	24.5	40.3
Federation of Rhodesia and Nyasaland	312.1	302.3	86.6	13.5	157.8	—	54.2
Ghana	58.8	58.8	13.1	—	37.6	—	8.1
Nigeria	238.9	238.9	55.1	—	79.2	—	104.5
Other African territories	689.3	658.6	20.6	143.4	121.4	67.1	336.8
India	812.7	812.7	395.4	30.2	126.1	53.1	208.0
Pakistan	233.9	233.9	61.1	—	5.2	—	167.7
Ceylon	16.2	16.0	3.8	—	8.7	—	3.7
Federation of Maltya	32.4	32.4	5.4	—	23.5	—	3.5
West Indies and Caribbean	66.8	62.2	6.1	0.7	46.3	5.1	8.6
All other Colonial territories	258.5	258.2	11.9	47.4	46.8	0.4	151.9
Commonwealth	7720.8	7463.5	866.8	1772.2	1637.9	331.1	3.1128

World (including U.S.S.R.)	33440	—	3450	6350	9850	13790	
				190	370	280	
Europe (excluding U.S.S.R.)	1220	—	380	690	1650	2410	
N. America	5320	—	570	910	2420	1480	
Latin America	5060	—	250				
Near East	2840	—	190	480	310	1860	
Far East	5170	—	900	680	1170	2420	
Africa	6180	—	550	1370	1620	2640	
Oceania	2110	—	60	1120	130	900	
			Per cent. of total area				
Commonwealth	100	97	11	23	21	4	40
World	100	—	10				
				19	29	41	
Europe (excluding U.S.S.R.)	100	—	31	16	30	23	
N. America	100	—	11	13	31	45	
Latin America	100	—	5	18	48	29	
Near East	100	—	7	17	11	65	
Far East	100	—	17	13	23	47	
Africa	100	—	9	22	26	43	
Oceania	100	—	3	53	6	38	

* Some of these figures are overstated since, where particulars of land area are not available, total area has been used
Source : F.A O. production yearbook, United Nations Food and Agriculture Organisation, 1959.

ENERGY

Apprendix 5. Energy production (figures relate to latest available year or period)

	Unit	World output	Commonwealth outpu	Commonwealth share , %
Coal . . .	million tons	2400	348	15
Crude petroleum .	million tons	940	113(a)	12
Natural gas . .	1000 millionft³	14499	439	3
Hydroelectricity .	1000 millionkWh	589	109	19
Total energy in coal equivalent (b) .	million tons	4233	525	12

(a) Including 79 million tons produced in the British Protected States of Bahrain, Kuwait, and Qatar in the Middle East. If these are to be excluded, the Commonwealth figure for total energy should be reduced to 422 million tons coal equivalent, which represents 10% of the world total.

(b) The conversion factors used are those given in the United Nations Statistical Yearbook, 1959.

Sources : Commonwealth Economic Committee publications ; Overseas Geological Surveys ; United Nations statistical yearbook.

Appendix 6. Consumption of commercial sources* of energy *per capita* in Commonwealth countries, 1958

	Metric tons of coal equivalent per capita
United Kingbom	4.741
Canada	5.137
Australia	3.644
New Zealand	1.934
South Africa	2.616
India	0.137
Pakistan	0.060
Ceylon	0.088
Rhodesia and Nyasaland	0.500
Gha na	0.139
Malaya	0.336

* Consumptions of non-commercial sources of energy, wood, bagasse, dung, etc., are not included in the above Appendix and no reliable estimates ahe available. They do, however, make a considerable contribution particularly with the less developed countries.

Source : United Nations world energy supplies 1955-1958, Series 1, No. 3.

Appendix 7. Industrial origin of gross domestic pro duct of Commonwealth countries

Country	Year	Gross domestic product at factor cost. Total value, £ sterling million	Percentage distribution of gross domestic product: Agiculture, forestry and fishing	Mining	Manufacturing industries	Construction	Other	Col. 1 as percentage of cols. 1–4
			1	2	3	4	5	6
United Kingdom .	1958	19778	4	4	35	6	51	8
Canada . . .	1958	10633		4	26	7	56	16
Australia . . .	July 1958 to June 1959	4397	17	3	33	—	47	32
New Zealand . .	April 1954 to March 1955	896	22	1	22	7	48	42
Union of South Africa	July 1957 to June 1958	1986	12	13	25		50	34
India . . .	April 1957 to March 1958	8510	47	1	17		35	72
Pakistan . .	April 1958 to March 1959	1616	54	—	12	—	34	82
Ceylon . . .	1958	412	51	—	5	9	35	78
Cyprus . . .	1958	79	23	10	10	5	52	48
Nigeria . . .	April 1956 to March 1957	807	63	1	2	11	23	
Federation of Rhodesia and Nyasaland .	1958	449	20	14	11	8	47	83
Malta . . .	1958	3S	7	9	9	—	75	28
Kenya . . .	1958	207	42	—	10	4	44	75
Tanganyika . .	1958	169	59	3	7	7	24	78
Mauritius . .	1958	50	30	—	21	4	45	55
British Guiana .	1956	43	25	11	11	10	43	44
Jamaica . .	1957	192	14	9	13	14	50	28
Trinidad and Tobago	1957	130	14	39	10	3	34	21

Source : United Nations statistical yearbook, 1959, except where otherwise indicated.

Notes : General : The estimates relate to gross domestic product at factor cost unless otherwise specified. The term 'gross' in this context means that the figures include depreciation, but the percentage contribution of each sector estimates the value added by the sector, and is therefore the best measure of the sector's contribution to the total product of the country. Columns 6 shows agriculture as a percentage of agriculture, mining, manufacturing and construction. Column 5 (Other) includes transport, utilities, wholesale and retail trade, public administration and defence.

Country Notes : *Australia* : Estimates by C.E.C. based on Australian figures for gross domestic product and for net production of primary and secondary industry Column 5 includes construction (column 4).

Union of South Africa : Total value = net domestic product at factor cost. Columns 3 and 4 relate to private enterprises only; Government enterprises in these and other industries except transport are classified in column 5.

India : Total value = net domestic product at factor cost. Columns 3 and 4 include utilities.

Pakistan : Total value = net domestic product at prices of 1949-52 Indirect taxes on exports included in column 5. Column 3 includes utilities. Column 5 includes construction (column 4).

Nigeria : Column 3 includes utilities and communications.

Federation of Rhodesia and Nyasaland : Source : Monthly digest of statistics for the Federation, June 1960, p. 9.

Malta : Column 2 includes construction (column 4).

British Guiana : Column 3 includes electricity.

Trinidad and Tobago : Column 2 includes oil refining.

Appendix 8. Primary products (figures relate to latest available year or period)

	Unit	World output	Common-wealth output	Common-wealth share, %
Wheat	million tons	245.3	34.0	14
Coarse grains	million tons	378.8	33.5	9
of which maize	million tons	188 4	11.0	6
barley	million tons	72.5	12.6	17
oats (a)	million tons	54.8	9.6	18
Rice	million tons	252.7	59.8	24
Milk (cows') (a)	million gal	60904	9535	16
Butter (excl. ghee) (a)	1000 tons	3791	627	17
Cheese (a)	1000 tons	2901	304	10
Beef and veal (a)	1000 tons	26715	3142	12
Mutton and lamb (a)	1000 tons	4951	1162	23
Pig-meat (a)	1000 tons	24664	1289	5
Oilseeds (as oil)	1000 tons	22678	5547	24
Sugar (cane and beet)	1000 tons	46888	7894	17
Tea	million lb	2004	1255	63
Cocoa	1000 tons	899	423	47
Tobacco	million lb	8262	1228	15
Rubber	1000 tons	1958	893	46
Wool (greasy basis)	million lb	5615	2850	51
Cotton	million lb	23491	2529	11
Jute (incl. allied fibres)	1000 tons	2474	1966	79
Hemp (hard)	1000 tons	805	270	34
,, (other)	1000 tons	380	81	21
Softwood	1000 m^3	835990	85123	10
Hardwood	1000 m^3	748310	84166	11
Iron-in-ore	million tons	191	22	12
Nickel-in-ore	1000 tons	284	168	59
Copper-in-ore	1000 tons	3400	918	27
Lead-in-ore	1000 tons	2300	594	26
Zinc-in-ore	1000 tons	2600	720	28
Tin-in-concentrates	1000 tons	154	51	33
Bauxite (a)	1000 tons	20700	8089	39
Manganese-in-ore	1000 tons	5430	1298	24
Asbestos	1000 tons	2023	1262	62
Phosphate rock	1000 tons	34000	2190	6

(a) Excluding China (mainland)

Sources : Commonwealth Economic Committee publications : Overseas Geological Survey; United Nations statistical yearbook.

Appendix 9. Secondary industry (figures relate to latest available year or period)

	Unit	World output	Common-wealth output	Common-wealth share, %
Crude steel . . .	million tons	300	33	11
Aluminium . . .	1000 tons	4030	588	15
Sulphuric acid . .	1000 tons	41140	4794	12
Cotton yarn . .	million lb	16628	299 0	18
Jute cloth . . .	1000 tons	2038	1306	64
Raw wool consumption (clean basis) .	million lb	3193	657	21
Man-made fibres .	million lb	6832	732	11

Source : Mineral Resources Division, Overseas Geological Surveys

Appendix 10. Estimated value of the British Commonwealth mineral production, 1959

Country	Value of production, £ million	Percentage of total value	Chief minerals produced (value £ million)
United Kingdom ...	930.3	31.84	coal (829.2), gravel and sand (25.2), limestone (19.2) iron ore (10.4), igneous rocks (10.2)
Canada ...	895.5	30.65	petroleum (156.9), uranium (123.1), nickel (95.5), copper (86.7), iron ore (71.6), gold (56·0), asbestos (39.9)
Union of South Africa	387.0	13.24	gold (250.1), uranium etc. (48.7), coal (27.7), diamonds (15.7), asbestos (9.6), copper (9.6)
Australia ...	170 3	5.83	coal (36.4), iron ore (27.2), lead (28.3), copper (20.5), construction materials (15.2), gold (12.6), zinc (1.0)
N. Rhodesia ...	125.5	4.30	copper (117.3), cobalt (3.2), zinc (2.5), lead (1.0), manganese (0.7)
India ...	107.2	3.67	coal (71.1), manganese (7.1), salt (4.5), iron ore (4.3), gold (4.0), petroleum (2.3).
Malaya ...	42.5	1.45	tin (29.3), iron ore (11.6), bauxite (0.8), gold (0.3)
Trinidad ...	36.5	1.25	petroleum (34.6), natural gas (1.4), natural asphalt (0.9)
Brunei ...	34.6	1.18	petroleum (34.3)
Ghana ...	26.9	0.92	gold (11.3), diamonds (8.4), manganese (6.8)
South-West Africa ...	26.4	0.90	diamonds (16.3), copper (4.8), lead (3.1), zinc (1 0)
S. Rhodesia ...	25.0	0.86	asbestos (7.4), gold (7.0), coal (3.8), chrome (3 0), copper (2.0).
Jamaica ...	20.7	0.71	bauxite (11.0), alumina (9.4), gypsum (0.3)
New Zealand ...	18.4	0.63	coal (7.9), sand (7.2), limestone (1.4), gold (0.5)
Sierra Leone ...	13.7	0.47	diamonds (9.7), iron ore (3.8)
Nigeria ...	9.9	0.34	tin (4.2), petroleum (2.7), coal (2.0), columbite (1.0)
Cyprus ...	9.5	0.33	copper (4.0), iron pyrites (2.0), cupreous pyrites (1.9), asbestos (0.9)
Tanganyika ...	7.2	0.25	diamonds (4.5), gold (1.2)
Pakistan ...	7.1	0.24	coal (3.6), petroleum (1.7), salt (0.8), natural gas (0.7)
British Guiana ...	5.4	0.19	bauxite (4.6), diamonds (0.6)
Kenya ...	5.3	0.18	cement (2.5), soda ash (1.7), copper (0.5)
Uganda ...	4.7	0.16	copper (2.7), cement (0.9)
Swaziland ...	2.1	0.07	asbestos (2.1)
Ceylon ...	1.6	0.05	cement (0.9), graphite (0.4), salt (0.2)
Fiji ...	1.2	0.04	gold (0.9), manganese (0.3)
Sarawak ...	1.0	0.03	bauxite (0.4), petroleum (0.3)
Other Commonwealth countries ...	6.5	0.22	phosphate rock (4.4), gold (0.6), salt (0.5)
	2922.0	100.00	

Source : Mineral Division, Overseas Geological Surveys.

Appendix 11. Estimates of Commonwealth mineral reserves

United Kingdom

Coal—anthracite and bituminous	168000 million tons
Iron (ore)	4600 million tons containing 1215 million tons iron
Petroleum	About 2 million tons
Potash	140 million tons of potassium oxide
Sulphur	60 million tons in anhydride and gypsum

Canada

Asbestos	The world's major producer of chrysotile, of which Canada's known reserves are the largest in the world	
Coal—bituminous	62400 million tons	Total : 98800 million tons
sub-bituminous and lignite	36400 million tons	

Canada (Continued)

Cadmium (metal)	22000 tons recoverable as a by-product in zinc production
Cobalt (metal)	2000000 tons
Copper (metal)	6 million tons, plus unproved reserves
Gypsum	Large reserves
Iron (ore)	At least 13635 million tons containing 5327 million tons iron
Lead (metal)	10 million tons measured and indicated
Magnesium (ore)	Large reserves
Manganese (ore)	150 million tons of low-grade material in New Brunswick
Natural gas	Over 25 million million ft³
Nickel	5 million tons, plus unproved reserves
Petroleum	Over 500 million tons
Phosphates	25 million tons of ore containing 20% apatite
Platinum metals	Very large
Potash	Recoverable reserves estimated at 17500 million tons potassium oxide
Sulphur	46 million tons in pyrites and sulphur-bearing minerals. Reserves recoverable from natural gas at present being tapped estimated at 40 million tons. Further large reserves in bituminous sands and gypsum-anhydrite deposits
Thorium (metal)	170000 tons
Titanium	One deposit with 150 million tons of ilmenite-haematite ore containing 35% titanium oxide; other deposits also known
Uranium (metal)	350000 tons
Zinc (metal)	14 million tons proved

Australia

Asbestos	Considerable reserves of blue asbestos (crocidolite). Relatively small reserves of other types of fibre
Bauxite	33 million tons proved and hundreds of millions of tons indicated in the deposits in Queensland
Cadmium (metal)	28000 tons recoverable as a by-product in zinc production
Coal—anthracite and bituminous	15250 million tons
sub-bituminous and lignite	42160 million tons
	Total : 57410 million tons
Copper (metal)	800000 tons proved plus other indicated reserves
Iron (ore)	720 million tons containing 419 million tons iron. Additional large reserves of lower-grade ore
Lead (metal)	13 million tons measured and indicated
Mica	Extensive
Rutile	2.5 million tons. Also reserve of ilmenite
Sulphur	14.9 million tons in pyrites and pyrrhotite and in lead and zinc sulphides. 140 million tons in gypsum
Thorium (metal)	40000 tons
Tin (metal)	30000—40000 tons
Tungsten (ore)	32 million lb of tungsten oxide
Uranium (metal)	12000 tons
Zinc (metal)	11 million tons measured and indicated
Zircon	About 1.5 million tons

Christmas Island

Phosphates	Over 30 million tons containing 80% tricalcium phosphate

Nauru Island

Phosphates	About 65 million tons containing 83% tricalcium phosphate

New Guinea

Bauxite	500000 tons

New Zealand

Coal—bituminous	124 million tons
sub-bituminous and lignite	908 million tons
	Total : 1032 million tons
Iron (ore)	496 million tons containing 250 million tons iron

Union of South Africa

Antimony (metal)	Estimates vary between 80000 and 150000 tons
Asbestos	Considerable reserves of chrysotile, amosite and blue asbestos. The only commercial source of amosite
Chrome (ore)	Largest free-world source of chemical-grade chrome ore. Total reserves 100 million tons of chemical-grade ore plus about 2 million tons of low-grade metallurgical ore suitable for blending
Coal—bituminous	67000 million tons
Copper (metal)	800000 tons proved, plus additional unproved reserves
Diamonds	Large
Gold	500 million ounces
Ilmenite	2 million tons
Iron (ore)	3500 million tons containing 1600 tons iron. Large reserves of lower-grade ore
Manganese (ore)	60 million tons containing 30-54% manganese
Phosphates	85 million tons containing 10-12% phosphorus pentoxide, with additional large reserves of lower-grade ore
Platinum metals	Large
Thorium(metal)	12000 tons
Tungsten (ore)	Large
Uranium (metal)	300000 tons

South-West Africa

Copper (metal)	Nearly 500000 tons
Diamonds	Very large
Iron (ore)	Possibly up to 300 million tons containing 120 million tons iron
Lead	1.3 million tons
Manganese	Large
Zinc (metal)	Nearly 500000 tons

India

Bauxite	28 million tons possibly of commercial grade
Coal—anthracite and bituminous	38100 million tons
sub-bituminous and lignite	4500 million tons
	Total : 42600 million tons
Copper	About 4 million tons proved and probable plus unproved reserves
Ilmenite	50 million tons
Iron (ore)	21300 million tons with an estimated 85000 million tons of lower-grade ore totalling 37940 million tons iron
Lead (metal)	About 100000 tons proved
Manganese (ore)	112 million tons, 60 million tons of which contain more than 45% manganese
Mica	No figures available. The free world's largest source of strategic grades of mica
Natural gas	1000 million ft^3
Petroleum	About 75 million tons
Phosphate	About 700000 tons containing 20-25% phosphorus pentoxide. Additional 8 million tons with 24-27% phosphorus pentoxide
Rutile	2 million tons
Thorium	240000 tons
Zinc (metal)	About 120000 tons proved and estimated

Pakistan

Coal—sub-bituminous and lignite	104 million tons
Iron (ore)	60 million tons containing 36 million tons iron
Natural gas	About 5 million million ft^3
Petroleum	About 3 million tons

Ceylon

Graphite	Large deposits
Ilmenite	4 million tons

Ghana

Bauxite	230 million tons
Diamonds	Extensive
Manganese	Still large but becoming depleted
Gold	Extensive

Federation of Malaya

Bauxite	Possibly 10 million tons
Coal—sub-bituminous	21 million tons
Ilmenite	Considerable
Iron (ore)	55 million tons containing 33 million tons iron
Tin (metal)	1.5 million tons plus reserves undeveloped

Cyprus

Copper (metal)	200000-250000 tons with additional unproved reserves

Nigeria

Coal—sub-bituminous	240 million tons
lignite	Over 60 million tons
	Total Over 300 million tons
Columdite	Mined with tin, Nigeria being the world's largest producer
Lead (metal)	About 100000 tons indicated
Petroleum	About 3.5 million tons
Phosphates	Small reserves known
Thorium	By-product of columbite working, 12000 tons
Tin (metal)	100000 tons proved and estimated plus an equal quantity as inferred reserves
Zinc (metal)	About 70000 tons indicated

Federation of Rhodesia and Nyasaland

Southern Rhodesia

Asbestos	Considerable reserves of chrysotile containing a high proportion of spinning-grade fibre
Chrome (ore)	6 million tons of metallurgical-grade ore. 80 million tons of chemical-grade chrome, commercial and sub-marginal deposits together
Coal—bituminous	Over 1000 million tons
Copper (metal)	Over 250000 tons
Iron (ore)	144 million tons containing 86 million tons iron. Further large reserves of lower-grade ore
Lead (metal)	210000 tons
Lithium minerals	Large
Phosphates	37 million tons containing 8% phosphorus pentoxide
Zinc (metal)	450000 tons

Northern Rhodesia

Cobalt (metal)	Over 350000 tons
Copper (metal)	24 million tons. Extensive additional but unproved tonnage
Iron (ore)	50 million tons containing 32 million tons iron. Further large reserves of lower-grade ore
Lead (metal)	430000 tons proved, plus 300000 tons indicated
Manganese	Large deposits in northern part
Zinc(metal)	700000 tons proved plus 700000 tons indicated

Nyasaland

Bauxite	60 million tons, averaging 43% alumina
Thorium (metal)	8000 tons

Kenya

Copper (metal)	30000 tons in proved, inferred and indicated ore
Graphite	100000 tons with 10% graphite
Soda ash	Large

Uganda

Cobalt (metal)	20000 tons. Also 7 million tons of inferred ore
Copper (metal)	200000 tons, plus 7 million tons of inferred ore
Phosphates	Over 200 million tons containing 13% phosphorus pentoxide

Tanganyika

Coal—bituminous	Over 250 million tons
Copper (metal)	14000 tons
Diamonds	Extensive
Lead (metal)	Minable reserves estimated at about 10000 tons

Sierra Leone	
Diamonds	Extensive
Iron (ore)	200 million tons containing 120 million tons iron. Further reserves of lower-grade ore
Rutile	Large reserves
British Borneo	
Petroleum	About 75 million tons in Brunei and Sarawak
Phosphates	60000 tons containing 10-20% phosphorus pentoxide
Bauxite	5.5 million tons in Sarawak
Hong Kong	
Iron (ore)	10 million tons containing 4 million tons iron
Jamaica	
Bauxite	500—600 million tons with an average recoverable alumina content of 42%
Gypsum	13 million tons minimum
Phosphates	160000 tons containing 25-31% phosphorus pentoxide
Trinidad	
Petroleum	55 million tons
British Guiana	
Bauxite	About 70 million tons containing 60% alumina
Columbite	1 million yd^3 averaging 2 lb of columbite concentrates per yd^3
Diamonds	Considerable
Gold	Considerable low-grade alluvial deposits
Manganese (ore)	About 5 million tons of 40% grade
Fiji	
Manganese	Many small deposits are known
Phosphates	Up to 200000 tons iron-aluminium phosphate
British Solomon Islands	
Phosphates	8 million tons iron-aluminium phosphate
Ocean Island	
Phosphates	About 8 million tons containing 85% tricalcium phosphate
Seychelles	
Phosphates	Small reserves known
Swaziland	
Asbestos	Considerable reserves of chrysotile
Coal—anthracite	About 35 million tons
Iron (ore)	62 milion tons containing 40 million tons iron. Further 280 million tons of lower-grade ore.

Source : Economic development in the Commonwealth, Central Office of Information, 1060.

TRANSPORT AND COMMUNICATIONS

Appendix 12. Railways and telephones

	Railways		Telephones
	Route distance	Total track	
United Kingdom . .	18565	50510	7532000
Canada , ...	44209	59394	5118253
Australia	26331	32693	2122251
New Zealand . . .	3400	—	641342
South Africa . . .	13438	17870	828434
India	34750	50369	475000
Pakistan (East and West)	7050	—	63000
Ceylon	900	—	30017
Ghana	600	—	24917
Malaya	1025	1303	61736
Nigeria	1780	—	40000
Southern Rhodesia .	1284	—	21291

Source : Official national statistics

SCIENTIFIC RESEARCH

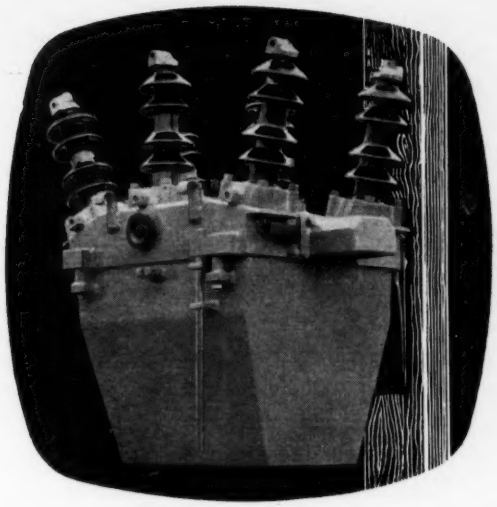
Appendix 13. Commonwealth Institutes and Bureaux

Commonwealth Mycological Institute, Kew
Commonwealth Institute of Entomology, British Museum
Commonwealth Institute of Biological Control, K.W. Neatby Building, Ottawa

Commonwealth Agricultural Bureaux.

Animal Breeding and Genetics, Edinburgh
Animal Health, Weybridge
Animal Nutrition, Aberdeen
Dairy Science and Technology, Reading
Forestry, Oxford
Helminthology, St. Albans
Horticulture and Plantation Crops, East Malling
Pastures and Field Crops, Hurley
Plant Breeding and Genetics, Cambridge
Soils, Rothamsted

(*Continued on page* 34)



TYPE-OYT

Service Voltage	*up to 15 kV*
Making-capacity	*10,100, pk amps*
Breaking-capacity	*75 MVA*
Power-frequency withstand	*50 kV*
Impulse withstand	*110 kV*
Overcurrent coils	*15 to 200 amps*

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KARACHI & LAHORE

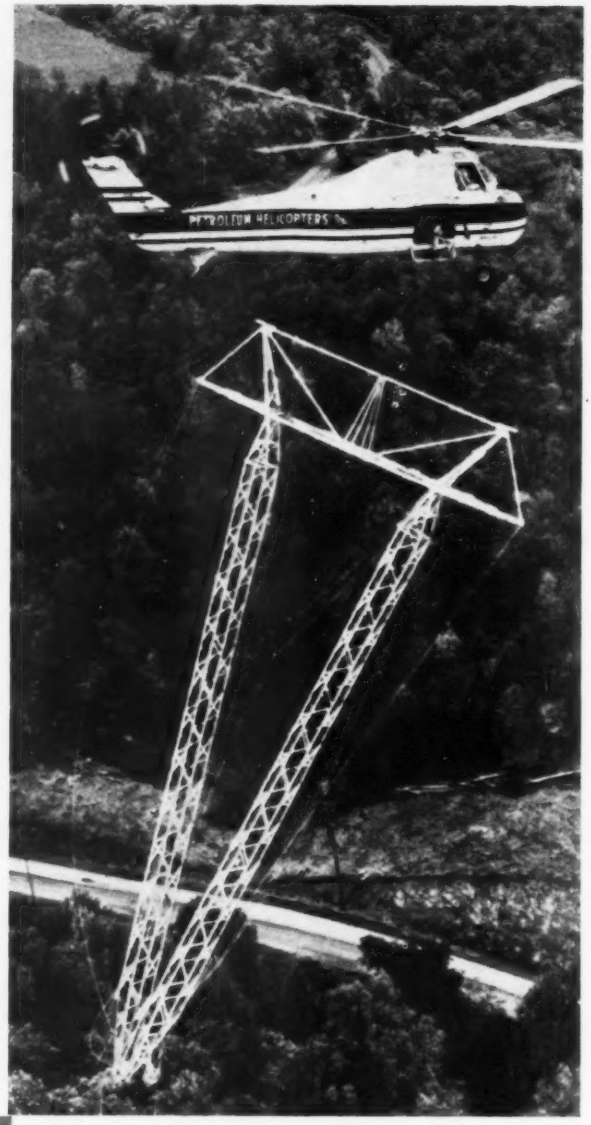
MYA SEIN CO., LTD.
RANGOON

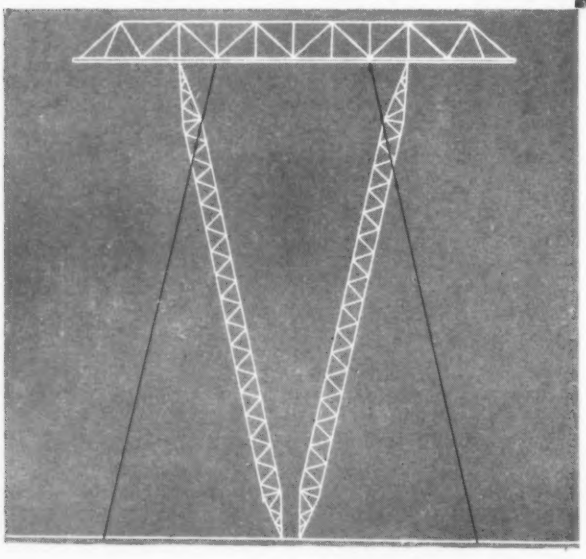
ARTISANS LIMITED
COLOMBO

ALUMINIUM for TRANSMISSION TOWERS

Just as aluminium is gaining increasing acceptance for transmission and distribution lines, so too by virtue of its lightness it is finding greater application for transmission towers, especially since the development of the Alcan Guyed Tower illustrated here. The Alcan tower is approximately one sixth the weight of a conventional steel tower or just over one third the weight of a similar design made in steel, a striking weight-saving achieved by using specially designed shapes extruded in Alcan B51S.

Among its other advantages, an Alcan guyed tower can be carried over inaccessible country by helicopter, as the Sikorsky helicopter shown here at the site of American Electric Power in Virginia illustrates. This project and several others in North America have provided ample tests to corroborate Alcan's own experience on the 4-year old installation in their 345KV Chute-des-Passes line. For transmission towers as well as for transmission and distribution lines, cheap and light-weight aluminium is here to stay.





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International Bank for Reconstruction and Development

EXCERPTS FROM THE SEVENTH ANNUAL REPORT 1960-61

THE BANK HAS NOW COMPLETED ITS FIFTEENTH year of operations. In the year, the activities of the Bank were part of a broadening stream of financial and technical assistance to the less developed countries. The Bank itself was joined by a new affiliate: the International Development Association, designed to aid economic growth with credits bearing less heavily on the balance of payments of underdeveloped countries than conventional loans. Further progress was made with other international initiatives to increase the flow of development funds and to coordinate efforts to assist economic development. The Inter-American Development Bank began its operations; and the first pre-investment survey financed by the United Nations Special Fund was completed, with the World Bank acting as Executing Agent. The 10 governments in the Development Assistance Group continued their consultations, and several of them took steps to establish institutional arrangements or funds that would facilitate their extension of aid to the less developed countries. The Bank itself took a leading part in the consideration by particular groups of governments of specific problems: external finance for the Indus River Settlement Plan and for the Five-Year Plans of India and Pakistan. Throughout, the Bank continued to cooperate with the capital markets and with private institutional investors in raising capital for economic development.

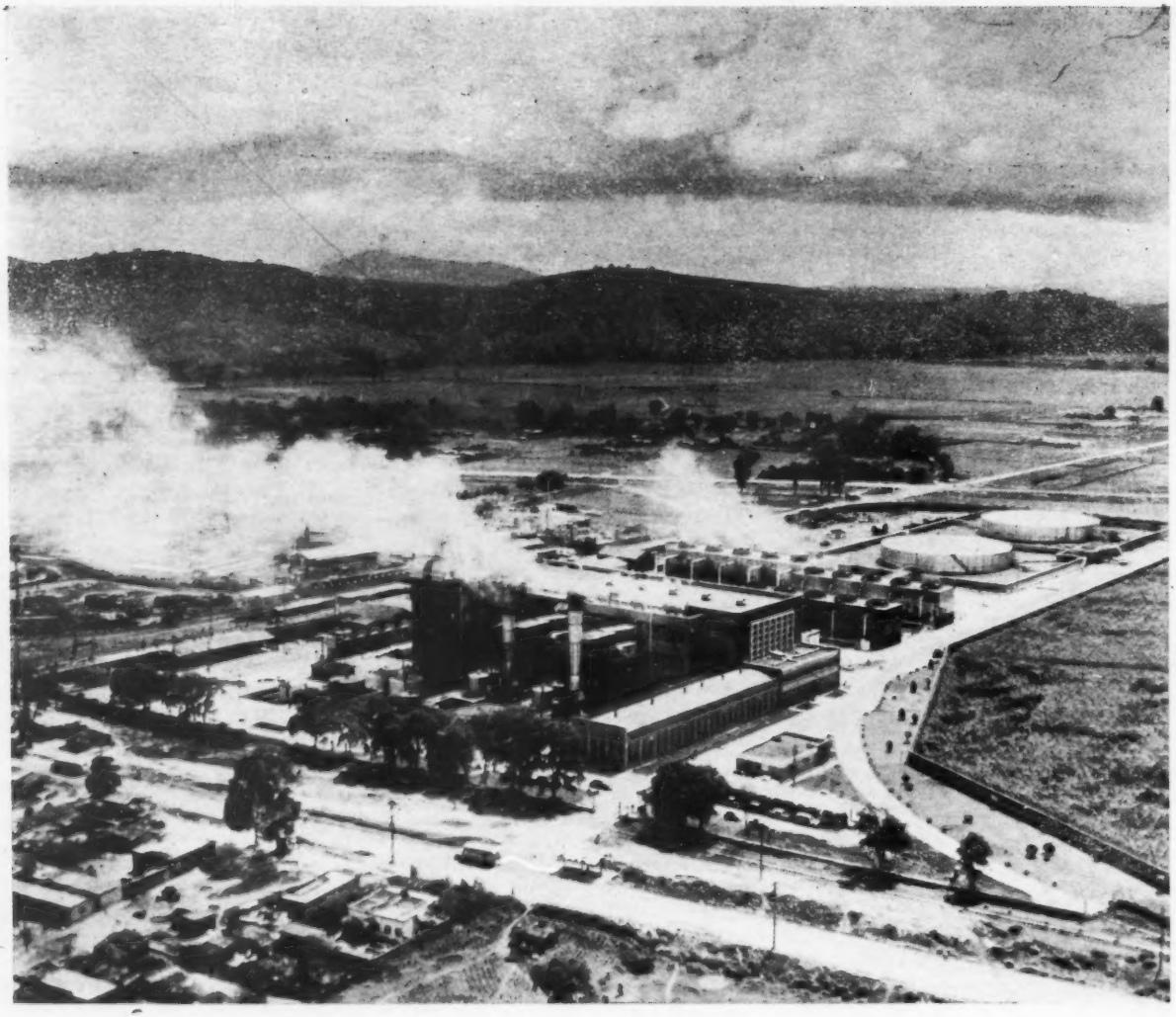
Together, the Bank and the International Development Association (IDA) committed a total of $711 million in loans and credits. The Bank lent $ 610 million despite the increase in other sources of public finance for development, and despite the postponement, for purely procedural reasons outside the control of the Bank, of a number of pending loans beyond the end of the fiscal year. This increased the total of its commitments, net of cancellations and refundings, to $ 5,669 million, of which almost half has been committed during the past four years. During the second half of the fiscal year, there was a marked increase in the number of project appraisals completed by the staff.

IDA came into existence on September 24, 1960. It has since carried out its first transactions, providing the equivalent of $101 million in the form of 50-year, interest-free development credits to four countries. IDA has a separate legal existence and its own funds, but is administered by the same officers and staff as the Bank; its first Annual Report is being published separately from this Report of the Bank. IDA has had a considerable impact on the work of the staff, involving the investigation of a wider variety of projects than are financed by the Bank and the dispatch of missions to countries where the Bank, with its more exacting financial terms, was not able to lend. These investigations and missions are implementing the policy that IDA projects shall be as thoroughly prepared as those financed by the Bank, to ensure the maximum economic benefit in the countries which borrow from the new Association.

The Indus Basin Settlement passed from negotiations to action during the years. It was embodied in the Indus Waters Treaty, 1960, signed in Karachi on September 19, 1960, by Shri Jawaharlal Nehru, Prime Minister of India, Field Marshal Mohammad Ayub Khan, President of Pakistan, and Sir William Iliff, Vice-President, on behalf of the Bank. Signature of the Treaty marked the end of a critical and long-standing dispute between India and Pakistan, and opened the way to the use and development of water resources on which depends the livelihood of some 50 million people in the two countries.

Simultaneously with the signing of the Indus Waters Treaty, an international financial agreement was executed in Karachi by representatives of the Governments of Australia, Canada, Germany, New Zealand, Pakistan, the United Kingdom and the United States, and of the Bank. This agreement created an Indus Basin Development Fund to finance the construction of irrigation and other works in Pakistan consequent on the Treaty settlement. The Fund will be administered by the Bank and will be financed with the equivalent of about $ 641 million to be provided by the participating governments, with a payment of approximately $ 174 million to be made by India under the Treaty, and with $ 80 million out of the proceeds of a Bank loan to Pakistan.

A general outline of the Settlement was given in last year's Annual Report. Work has now begun on the ten-year task of constructing the works included in the Settlement Plan. Preliminary construction is already under way on several works and tenders are



Mexico—Lecheria Thermal Power Plant

now being invited on major projects. The storage reservoirs and link canals in the Plan include several which are the biggest of their kind ever to be undertaken anywhere in the world. International groupings of contractors have been formed, enabling them to pool their resources and submit tenders for these projects.

Both India and Pakistan have now embarked on new development plans on a large scale, requiring a large amount of external assistance. The Indian Third Five-Year Plan began in April 1961 and the total investment involved, public and private, is the equivalent of more than $ 20,000 million. About three-quarters of this will be met from India's own resources ; foreign exchange assistance is needed in the form of investments, loans and grants totaling over $ 6,000 million. The Pakistan Second Five-Year Plan began in July 1960. Present estimates indicate that it will involve a total investment equivalent to over $ 4,000 million by 1965, with external financing required in one form or another to the extent of almost one-half of that total.

To help in meeting this situation, the Bank and some of the principal capital exporting countries are making use of a method which was first used in the later years of the Indian Second Five-Year Plan. In 1958, when India was experiencing balance of payments difficulties, the Bank called a meeting of a Consortium of member countries interested in the financing of India's economic development ; as a result of this and further meetings in 1959 and 1960, additional large-scale assistance was provided to India. In the months before the Third Five-Year Plan came into operation, it was analysed in detail

by the Bank and this analysis was submitted to the Consortium countries.

At a meeting late in May the members of the Consortium gave particular consideration to India's needs in the first two years of the Plan and undertook to provide aid to India totaling over $ 2,000 million. The accompanying table shows the commitments made, subject as appropriate to legislative action or other necessary authorization.

PROGRAM OF AID TO INDIA'S THIRD FIVE-YEAR PLAN

Expressed in millions of U. S. Dollars: Indian fiscal years

	1961-62	1962-63	Two-Year Total	1963/64-1965/66	Total
Canada . . .	28	28	56	—	56
France . . .	15	15	30	—	30
Germany . .	225	139	364	61	425
Japan . . .	50	30	80	—	80
United Kingdom	182	68	250	—	250
United States .	545	500	1,045	—	1,045
World Bank and IDA . . .	250	150	400	—	400
Total . . .	1,295	930	2,225	61	2,286

This program of aid should enable India to launch her Third Five-Year Plan of economic development with confidence in the achievement of its objectives. Another meeting will be held later in 1961 to consider additional aid for the second year of the Plan.

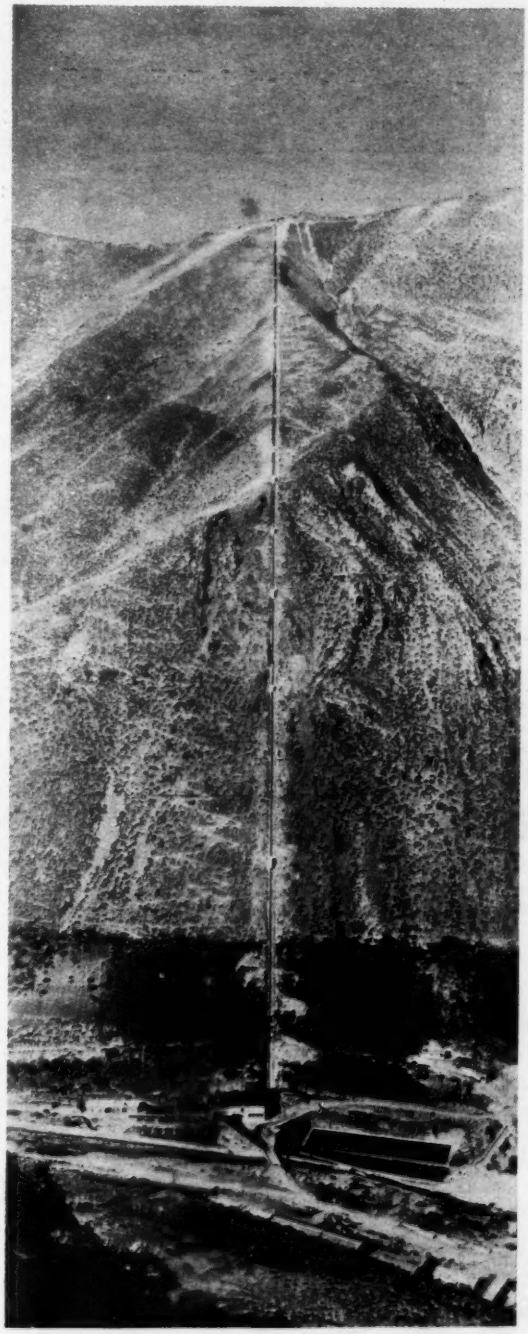
A similar Consortium was set up to consider the needs of Pakistan and first met in October 1960. In this case also the Bank made an exhaustive examination of the Pakistan Second Five-Year Plan and a second meeting of the Pakistan Consortium took place early in June 1961. This meeting resulted in substantial additional help for Pakistan, sufficient assistance being recommended by members of the Consortium to sustain the momentum of development and to enable Pakistan to pay for essential imports in 1961-62, the second year of the Plan. A meeting will be held later this year to consider the extent and nature of assistance from the Consortium for the second and third year of the Plan period.

The amounts that would be provided by participants in the Consortium, subject as appropriate to legislative or other necessary authorization, are shown in the accompanying table. The first column represents the recommendations made during the meeting for additional commitments, and the second column represents commitments made since the beginning of the Second Plan.

The Year's Lending

New lending during the fiscal year totaled $ 609,890,000. There were 27 loans, bringing the total number of the Bank's loans to 292 in 57 member countries and territories. This last figure illustrates the world-wide scope of the Bank's operations; it includes four countries which received first loans from the Bank during the year—Argentina, British Guiana, Israel, and Uganda.

More than two-thirds of the Bank's lending is

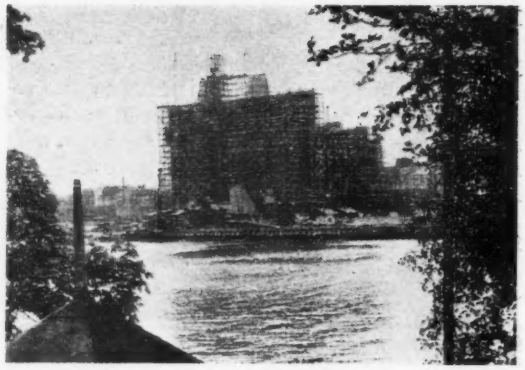


Chile—Los Molles Hydroelectric Project.

PROGRAM OF AID TO PAKISTAN'S SECOND FIVE-YEAR PLAN

Expressed in millions of U. S. Dollars : (Pakistan fiscal 1961/62)

	Recommended Additional Commitments	Already Committed	Total
Canada	18.0	19.8	37.8
France	10.0	—	10.0
Germany	25.0	37.5	62.5
Japan	20.0	20.0	40.0
United Kingdom	19.6	22.4	42.0
United States	150.0	129.6	279.6
World Bank and IDA	77.8	—	77.4
Total	320.0	229.3	549.3



Finland—Helsinki Thermal Power Plant.

for basic investment in transportation and electric power, and in the past few years loans for transportation have been slowly drawing ahead. This trend was markedly in evidence this year, with transportation loans accounting for $ 311 million. Railway improvements made up the bulk of this total, including two large loans—$ 70 million to India and $ 80 million to Japan for the improvement and expansion of their rail services. Other railway borrowers were Burma, Colombia and Thailand. Loans to assist road development and maintenance in Argentina, Chile, Mexico, Panama and Peru totaled $ 92 million, and a loan of $ 27.5 million helped to finance the construction of a new Mediterranean port for Israel.

Electric power loans of the year totaled $ 125 million and were widely spread throughout the world. In all, eight loans were made for this purpose, one in Africa (Uganda), two in Asia (Ceylon and Japan), three in Latin America (Colombia, Costa Rica and El Salvador) and two in Europe (Norway and Yugoslavia). It is estimated that these loans will help to add more than a million kilowatts of capacity in the countries concerned.

Loans for agriculture amounted to $ 126 million. This total was mainly accounted for by the loan of $ 90 million made to Pakistan as the Bank's contribution to the financing of the large irrigation works required to implement the settlement reached in the Indus Waters Treaty, 1960. The other loans for agriculture assisted agricultural credit in British Guiana and irrigation projects in Mexico and the Sudan.

Industrial lending totaled $ 48 million, made up of loans for steel in Japan and for industrial developmet banks in India and Pakistan. Both the development bank loans provide additional foreign exchange assistance to institutions which had previously received Bank funds.

Technical Assistance

The past year saw the highest level of activity yet reached by the Bank in providing assistance to its member countries through general economic surveys, which examine the development potential of the country concerned and recommend the main directions which planning and investment should take. The report of the general survey of Libya was published in October, the Tanganyika mission report in March and the Venezuela mission report in May. The general survey of Uganda, which began in

LIST OF LOANS

Expressed in United States Dollars

Country	Purpose	Amount
Argentina	Transport—roads	$ 48,500,000
British Guiana	Agriculture	1,250,000
Burma	Transport—railwayy	14,000,000
Ceylon	Power	15,000,000
Chile	Transport—roads	6,000,000
Colombia	Power	22,000,000
	Transport—railways	5,400,000
Costa Rica	Power	8,800,000
El Salvador	Power	3 840,000
India	Industry—development bank	20,000,000
	Transport—railways	70,000,000
Israel	Transport—port	27,500,000
Japan	Industry—steel	6,000,000
	Industry—steel	7,000,000
	Power	12,000 000
	Transport—railways	80,000,000
Mexico	Agriculture	15,000,000
	Transport—roads	25,000,000
Norway	Power	25,000,000
Pakistan	Agriculture	90,000,000
	Industry—development bank	15 000 000
Panama	Transport—roads	7,200,000
Peru	Transport—roads	5,500,000
Sudan	Agriculture	19,500,000
Thailand	Transport—railways	22,000,000
Uganda	Power	8,400,000
Yugoslavia	Power	30,000,000
	Total	$ 609,890,000

Thailand—Yanhee Multipurpose Project.

Australia—High Eildon Earth-Filled Dam.

September, has reached the stage of a draft report and publication is expected by early 1962. A large general economic survey mission was sent to Spain, and recruitment began for a general economic survey mission which the Bank has agreed to send to Kenya in September 1961.

Development advisory missions were sent to Kuwait, the Philippines and Chile. The mission to study agricultural problems in Ireland completed its field work during the year and its report will soon be ready for transmittal to the Government. The work of the Food and Agriculture Inquiry Commission in Pakistan, which the Bank and FAO assisted in staffing, was completed during the year.

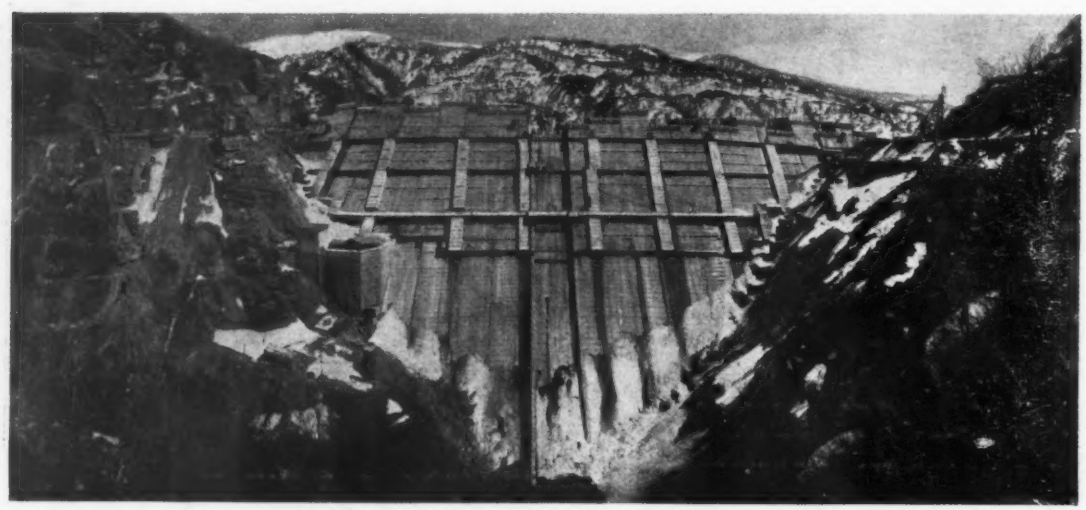
The Bank continued to provide advisory assistance in other forms to the extent that its personnel resources permitted. Staff members remained as resident representatives in Thailand, Pakistan, Ethiopia and India. At the request of the Government of Nigeria, the Bank gave leace of absence to one of its senior staff members to serve as adviser to the government for a two-year period beginning in November 1960. The staff member serving as adviser to the Pakistan Industrial Credit and Investment Corporation Limited remained in Karachi. A staff specialist was sent to Peru to advise on land settlement and allied questions arising from the completion of irrigation works which had been assisted by a Bank loan made in 1955. A staff member was assigned to serve as a member of the Transportation Planning Group, organized by the Bank as Executing Agent for the UN Special Fund to prepare a long range transportation program in Argentina. An important development in technical assistance during the year was the Bank's agreement to finance from its own funds part of the foreign exchange costs of comprehensive transportation studies in Colombia and Peru. These studies are being undertaken by consulting engineering firms working closely with government officials under terms of reference drafted with the Bank's help.

Where staff members have not been available, the Bank has offered its assistance in recruiting outside experts for employment directly by member governments. In response to requests of this kind, the Bank recommended an economic adviser to the Government of Malaya, and an industrial economist for the staff of the Pakistan Industrial Credit and Investment Corporation.

Close co-operation has continued with the UN Special Fund. The final report of the survey of electric power needs and potential of Argentina, the first Special Fund project for which the Bank served as executing Agency, was submitted to the Government and to the Special Fund early in the fiscal year. In addition to the other Special Fund projects in Argentina, British Guiana, Nigeria, Surinam and Thailand for which the Bank had previously agreed to serve as Executing Agency, it has now agreed to serve in the same capacity for a study of power and irrigation potentialities in Guatemala and a survey of natural resources, power and highways in central Peru.

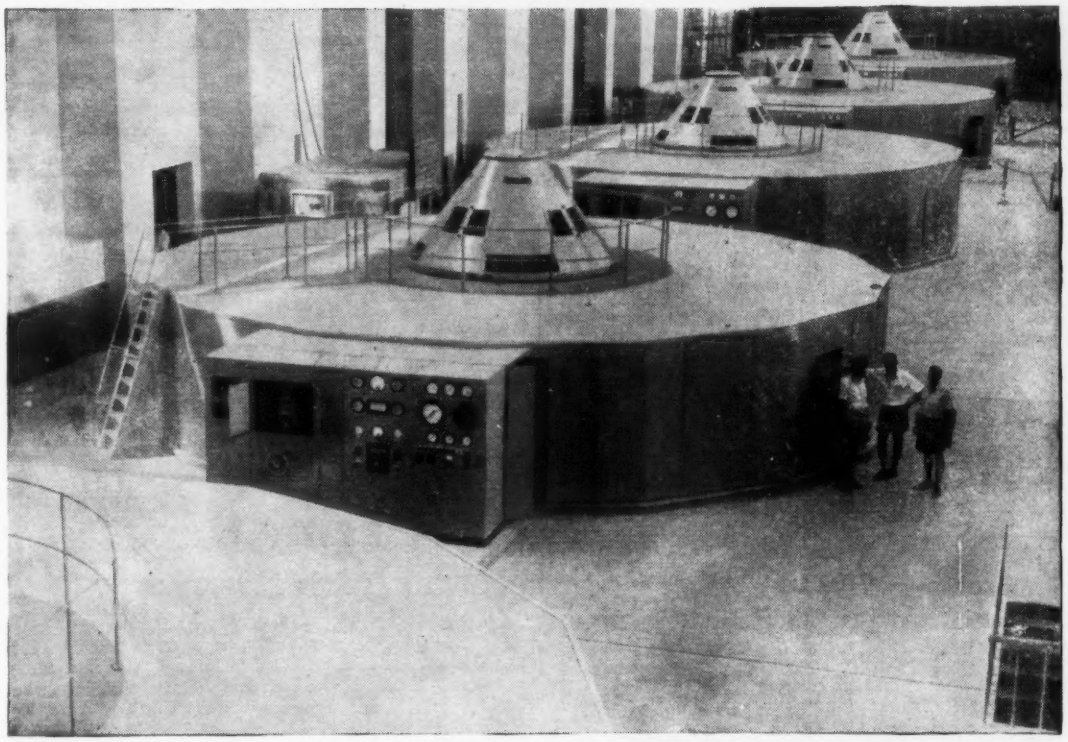
The Bank has continued to assist member countries in the establishment or reorganization of industrial development banks. At the request of the governments concerned and of private sponsors, Bank missions have visited Colombia and Chile to advise on the possibility of setting up private industrial financing institutions for these countries. A reorganization of the Banco Industrial del Peru is progressing, based on recommendations made by the Bank. The Bank has also provided training at headquarters for key staff members of several develop-

Japan—Arimine Hydroelectric Project.



'ENGLISH ELECTRIC'

GENERATING SETS FOR RIHAND POWER STATION



The English Electric Company has supplied five 77,000 B.H.P. Vertical Shaft Francis Turbines coupled to 55,500 KVA, 11 KV Umbrella type Generators for the Rihand Power Station in the U.P. The Company has also supplied all the H.T. & L.T. indoor Switchgear, Control and Relay Boards, Station and Unit Transformers and all ancillary equipment.

Every aspect of hydro-electric design and manufacture is dealt with inside the Company's organisation and comprehensive hydro-electric installations in India by 'English Electric' include Sengulam, Radhanagari, Nizamsagar and Sarda Power Stations. Hydro-electric equipment has also been supplied for the Power Stations at Bhira, Hirakud, Poringalkuthu, Papanasam and Mettur.

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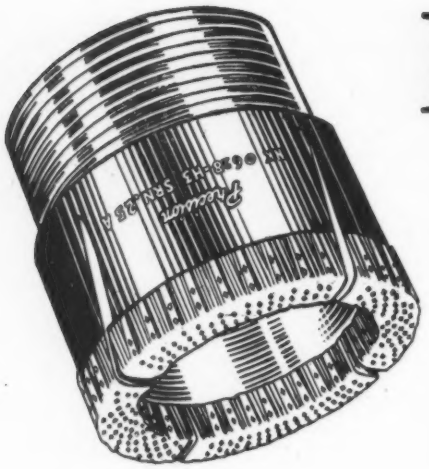

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ment banks and has continued to give advice to many countries on development banking problems.

The sixth course of the Bank's economic development staff college, the Economic Development Staff College, the Economic Development Institute, was held from October 1960 until April 1961. The final two weeks of the course were spent in Southern Italy and Sardinia, studying aspects of the development program for Southern Italy. The staff and participants of the Institute were guests of the Italian Government and Cassa per il Mezzogiorno. Participants in this year's course numbered 24, of whom eight were from Asia, four from the Middle East, four from Africa, four from the Caribbean area, three from Europe and one from the staff of the Bank. A total of 118 participants from member countries or territories, and five from the Bank, have attended the regular courses of the Institute since it began in January 1956.

At the suggestion of FAO, the Institute arranged to hold a special five-week course in June and July for agricultural economists, mostly from FAO, designed to give them an opportunity to review some of the broader problems of development programming, project appraisal, and the establishment of priorities in public investment programs.

During the year the Economic Development Institute brought to fruition a library program which had been under study for some time. The financing of this project is being shared by the Rockefeller Foundation ; it is designed to meet the need expressed by Fellows of the Institute when they returned to home posts to have available the kind of reading and reference material to which they were introduced during their stay at the Institute. The libraries, which are offered to governments, central banks and other public institutions, consist of approximately 400 books, articles and papers, in English, on development problems. Eighty-five of these libraries had been offered and accepted by th end of June 1961 ; distribution will begin as soon as the materials have been assembled. Each recipient is asked to give a general undertaking to provide space for the library, to take care of it and to make it available to those who can benefit from it. No financial contribution is required, but preference has been given to the agencies or ministries in which Fellows are employed. The Institute is engaged in planning similar libraries in French and Spanish. A substantial amount of translation of general and technical works will be required.

The training program for junior officials from the Bank's member countries was continued, ten trainees from as many countries taking part in 1961. One hundred and eleven trainees, from 58 countries, have now participated in the General Training Program. In addition eight senior officials of member countries received individual training, under the Bank's Public Finance and Special Training Program. Since the Bank started these Programs, 63 senior officials from 32 countries have received specialized training.

For a number of years the Bank and the United Nations exchanged information and co-ordinated their technical assistance and other developmental activities through an informal liaison committee. By a provision of the relationship agreement entered into between the International Development Association and the United Nations early in 1961, this committee was given formal status. It consists of the Secretary-General of the United Nations, the Managing Director of the UN Special Fund, the Executive Director of the UN Technical Assistance Board and the President of the Bank and IDA, or their designated representatives.

Bank Loans Classified by Purpose and Area
JUNE 10, 1961

(Millions of U.S. Dollars, net of cancellations and refundings)

	Total	Africa	Asia and Middle East	Australia	Europe	Western Hemisphere
Electric Power						
Generation and Distribution	1.740.9	186.4	479.3	29.2	388.0	657.9
Agriculture and Forestry	496.3	50.7	169.5	103.4	87.8	84.9
Farm Mechanization	121.1	—	—	89.4	2.0	29.7
Irrigation and Flood Control	306.5	35.0	154.9	6.0	73.3	37.3
Land Clearance : Land and Farm Improvement	40.9	13.7	13.6	6.0	2.1	5.5
Crop Processing and Storage	7.0	1.0	—	—	4.2	1.8
Livestock Improvement	12.9	1.0	1.0	—	—	10.6
Forestry	8.2	—	—	2.0	6.2	—

M. C. Pani

Major and Medium Irrigation Projects in Orissa during Third Plan

Salandi Irrigation Project

SALANDI IRRIGATION PROJECT IS ONE OF THE BEST projects which may be considered as productive in the category of Medium Irrigation Projects. The project comprises of a composite dam 2688 ft. long across the Salandi at Hadgarh in Keonjhar District. The length of the masonry dam is 582 ft. having a spillway section of 376 ft. The maximum height of the dam is 170 ft. The lake to be formed after the erection of the dam will be about 13.29 sq. miles at F.R.L. 270.00

The project is estimated to cost Rs. 5.10 crores, and will irrigate 2,25,000 acres on the left side of the Salandi river extending upto the Burabalang river. Jute, sugarcane, mung, vegetables etc. can be grown besides paddy and the total annual irrigation will be 3,27,500 acres.

The reservoir will also moderate Salandi floods and an area of about 50,000 acres in the Salandi delta area will be protected from floods considerably.

The cost of the dam and its appertenant works will be of the order of Rs. 2.72 crores and the balance Rs. 1.94 crores will be spent on 200 miles of new canals involving 30 crores cft. of earthwork. The project would provide a man-power-employment of 76.5 lakhs man days during the period of construction which is reckoned at about 5 years.

The total annual revenue is expected to be Rs. 19.53 lakhs after accounting for work expenses to the tune of Rs. 7.87 lakhs a year, thereby yielding a net return of 4.85% at the end of the 20th year of construction.

Preliminary works like contour survey of the ayacut and reservoir areas, exploration of the dam foundation, bottom areas etc. have been completed. Construction of approach roads buildings and collection of materials are almost completed. Excavation of main canal and distributaries has been taken up. The work in the spillway section of the masonry dam is also started.

Bhimkund (Birgobindpur) Project

The demand for power in recent years is outgrowing the present arrangements for generation of power both hydro and thermal due to acceleration of industrial development. To provide power for economic growth of several industries, Bhimkund project on the Baitarani has been given preference over other multipurpose projects as Rengali and Tikerpara Projects.

Besides generation of electricity and flood control in the Baitarani Delta, the project envisaged irrigation also. The water to be released from the main power house at Nawapara will be picked up at Birgobindpur where a barrage will be constructed to irrigate 1,05,000 acres on left in Anandapur and Bhadrak subdivision and 73,000 acres on the right in Anandapur and Jajpur subdivision. 150% of irrigation is proposed and the total annual irrigation will be to the extent of 2,67,000 acres.

The barrage will be 931 ft. long having 14 spans of 60 ft. each. Gates will be installed to head up water for irrigation.

The barrage and canal system therefore is estimated to cost Rs. 5.07 crores of which Rs. 1.50 crores will be expenditure during the third five year plan.

The total annual revenue after completion would be Rs. 16.33 lakhs after taking into account working expenses to the tune of Rs. 5.65 lakhs. thereby yielding a return of 2.9% at the end of 20th year of construction. The project will provide a man-power-employment of 24.44 lakhs during the Third Five Year Plan.

Detail Investigation of the Project is in progress. The project awaits the approval of the Planning Commission.

Salki Irrigation Project

Salki Irrigation Project in the district of Phulbani envisages construction of a diversion weir near Paljhar across river Salki, a tributary of the Mahanadi.

The project on completion will irrigate 40,000 acres of paddy and 5000 acres of rabi. The project is estimated to cost Rs. 52.85 lakhs.

The diversion weir 510 ft. long has been completed. Works on Right canal system have nearly been completed except a few cross drainage works. It is expected that irrigation benefits will be extended to the right ayacut during the coming monsoon.

The total annual revenue is expected to be Rs. 2.97 lakhs after accounting for working expenses. The projevt will provide a man-power-employment of 8.46 lakhs man days and will be completed within third five year plan period.

Budhabudhiani Irrigation Project

A dam across the Derant, a sub-tributary of the Mahanadi will be constructed in Nayagarh at a cost of Rs. 35.80 lakhs to irrigate 6,000 acres during khariff and 2700 acres during rabi.

Preliminary works like approach road, buildings and collection of materials have been taken up in hand. The project is scheduled to be completed during third five year plan.

The dam will be 4290 ft. long of which 90 ft. will be spillway. It will be maximum 82ft. high above deepest bed level.

The total annual revenue is expected to be Rs. 51,270/- after taking into account working expenses. The project will yield a return of 1.18% maximum and will provide man-power employment of 5.72 lakhs man days.

Delta Irrigation Project (Major)

In order to utilise the released waters from Hirakud power house to the extent of 10,000 cusecs, extension of irrigation in the Mahnadi Delta has been planned. The project cost will be Rs. 25.00 crores and it will irrigate 10,77,000 acres in Cuttack and Puri Districts. Besides paddy other crops like jute, sugarcane, mung, potato etc. will also be irrigated and the total annual irrigation will be 17,58,000 acres.

The total annual revenue is expected to be Rs. 147.82 lakhs after accounting for working expenses to the tune of Rs. 30.45 lakhs, thereby yielding a return of 4.05% at the end of 10th year of construction. The project will provide a man-power-employment of 4.00 crores mandays.

Towards the close of 2nd Five Year Plan, construction works on this project started in full swing. The head works at Mundali was started in February-March, 1960 and it is expected that the whole work will be completed by May, 1962. Afflux bundh and left guide bank have been completed.

Major cross drainage works like syphons across the Kaukhai, Kushabhadra and Bhargovi were taken up in March, 1960 and are expected to be completed by May, 1962. Besides, several minor cross drainage works, road bridges, regulators and falls have been taken up in different reaches of the canal. About 22 miles of main canal and 98 miles of branch canals have been excavated and about 32 miles of main and branch canals are under construction.

The existing Jobra weir has been remodelled for a length of 1500 ft. and the Birupa weir for a length of 800 ft. About 102 miles of main canal and 150 miles of distributaries and minors have been remodelled and about 84 miles of main canal and 530 miles of distributaries and minors are being remodelled.

The entire project is expected to be completed in all respects by the middle of fourth Five Year Plan.

Salia Irrigation Project

A storage reservoir is proposed for irrigation purposes by damming river Salia near Paneshdihi in the district of Puri. Total length of the dam will be 1460 ft. and maximum 93 ft. high. Besides, dyke for a length of 6250 ft. of maximum height 32' will also be constructed. The lake area at F. R. L. will be 3.23 sq. miles.

The total cost of the project is estimated to be Rs. 69.78 lakhs for irrigating 20,000 acres during khariff in the districts of Puri and Ganjam.

The total annual revenue is expected to be Rs. 1.65 lakhs after accounting for working expenses to the tune of Rs. 50,790/-. The anticipated return on capital is 1.97% max. The project will provide a man-power-employment of 11.16 lakhs mandays.

Preliminary works like buildings, jungle clearance approach roads etc. have been started. The work will be mostly completed by the end of the third Five Year Plan.

Godahado Irrigation Project

It is proposed to form a reservoir across Godahado river at Bijoyanangargarh and a pick-up weir across Kantaikoli at Sankrakholi in Ganjam District at a cost of Rs. 40.43 lakhs to irrigate 7500 acres. Besides paddy, 3375 acres will also be irrigated during rabi season. The dam will be 5470 ft. long and maximum 79 ft. high.

The total annual revenue is expected to be Rs. 63,945/- and the anticipated return on capital would be 1.3% max. The project will provide a man-power employment of 6.47 lakhs man-days.

Preliminary works like construction of buildings for the staff and purchase of special tools and plants are being done. The work is expected to be completed in all respects within the third Five Year Plan period.

Dhanai Irrigation Project

The project envisages construction of a reservoir by building a dam across Dhanai river at a place about a mile d/s of village Borasingi in Ganjam District. The project is estimated to cost Rs. 32.10 lakhs and will irrigate 9500 acres of land during khariff and 3,000 acres during rabi. The dam will be 3600 ft. long and maximum 60 ft. high.

The total annual revenue is expected to be Rs. 72,000/- after accounting for working expenses to the tune of Rs. 19,000/- and the anticipated return on capital would be 2.16% maximum. The project will provide a man-power-employment of 5.14 lakhs man days.

Preliminary works like construction of buildings approach road and clearance of site are being done. The work will be mostly completed by the end of third Five Year Plan.

Others

Other medium irrigation Projects proposed to be taken up during the third Five Year Plan are the following : Pipalpanka, Siaria, Bahuda Stage I, Remodelling H. L. C. All the above projects are now under detail investigation.

N. Venkata Row

Speed and Pressure Regulation of the Hydraulic Turbines

THE DIAMETER OF A PENSTOCK HAS TO BE DECIDED after considering various alternatives with regard to cost, turbine regulation, diameter required at the scroll case entrance, mechanical strength etc.

On the basis of data obtained from various plants working satisfactorily Mr. Beir of Bureau of Reclamation, proposed the formula (1) for economical diameter of penstock :

$$D = (P/H)^{0.456} \qquad (1)$$

where P = horse power, H = head in ft., D = diameter in ft.

The penstock water velocities range from 5 ft./sec. in low head plants to 30 ft./sec. in high head plants.

Basing on existing installations Mr. Beir proposed another formula for the penstock velocity :

$$V = 0.125\sqrt{2gH} \qquad (2)$$

V = velocity of water ft./sec.

g = 32.2

For the calculation of the penstock thickness various formulæ have been proposed.

$$t = \frac{HD}{2+e} \qquad (3)$$

t = thickness in inches
D = diameter in inches
f = allowable stress—16,000 lbs/sq. inch
e = efficiency of joint (say 80%).
H = Pressure head inclusive of water hammer

About $^1/_{16}$" is added to the calculated value to take care of corrosion. Minimum thickness employed is $\frac{1}{2}$".

The formula employed by the French engineer is:

$$t = \frac{PDb}{2\,y\,y_1\,y_2}$$

b = factory of safety (1.25)
y = 30,000 lbs/sq."
y_1 = efficiency of the joint
y_2 = welding factor (0.925)

Some continental engineers use :

$$t = \frac{\text{Head} \times \text{diameter} \times 1.25}{2 \times 30{,}000}$$

In installations when the ratio of the penstock length to the head is about 3 to 4, the governor closing time, the flywheel effect etc. can be adjusted for satisfactory governing. If the ratio is more special precautions have to be taken.

The penstock factor $\frac{LV}{H}$ is a measure of the inertia of the water column. In a good design

$$\frac{LV}{H} > \frac{\omega R^2 N^2}{HP} \times 10^5$$

The speed of the turbine should be kept constant irrespective of variation of load. This is the function of the governor. On rejection of load the governor tends to stop or reduce, as the case may be, the flow of water. As the flow of water to the turbine starts reducing a pressure wave commences to travel up the penstock to the forebay or surge chamber. The pressure wave gets reflected back to the turbine inlet. The time for up and down travel of the wave is called the critical time.

The wave velocity is

$$a = \sqrt{\frac{g/W}{\frac{1}{K} + \frac{D}{Eb}}}$$

Plant	Head ft.	HP	Actual values			From eq.2		From eq.1	
			Q	V	D	V	D	V	D
			cusecs	ft./sec	ft.				
Hoover	380	115,000	2450	18.5	13	22	11.9	18.9	12.8
Grand Coulee	330	150,000	2500	17.7	18	18.2	17.7	19.1	17.3
Hungry House	400	105,000	2542	17.8	13.5	20	12.7	18	13.4
Shasta	330	103,000	2800	15.8	15	18.2	14	16.9	14.5

$g = 32.2$

$W = 62.5$ lbs/cft.

E = Modulus of elasticity of pipeline material

b = pipe thickness

D = pipe diameter

K = modulus of elasticity of water in compression

For steel penstock the above equation can be approximated to

$$a = \frac{4675}{\sqrt{1+0.01\frac{D}{b}}} \quad \ldots\ (4)$$

If the gates are closed within the critical time the kinetic energy of water produces a pressure increase. The pressure increase is called the water hammer. The magnitude of the power behind a water hammer can be judged from an example. Consider an 18ft. diameter 625 ft. length penstock. Assume that the mass of water is moving at 13 ft./sec. and alternator looses load with the result that turbine gates close in, say, 4 sec. The HP to decelerate the water is

$$\frac{\frac{1}{2}MV^2}{550t} = \frac{\frac{1}{2}\times 169\times 95{,}00{,}000}{550\times 4\times 32.2} = 11{,}300\ HP$$

This pressure increase is effected by a number of factors—length of conduit, velocity of water, etc.

The critical time can be represented by

$$T_c = \frac{2L}{a} \quad \ldots\ (5)$$

Jovkovsky proved that the water hammer produced is

$$\frac{\Delta H}{H} = \frac{aV}{gH} = \frac{2LV}{T_c gH} \quad \ldots\ (6)$$

eg. 1 : consider an installation with the following

$D = 18$ ft. $\quad H = 290$ ft. $\quad HP = 95000$

$L = 625$ ft. $\quad Q = 3250 \quad N = 187.5$

$Q = AV$

$$V = \frac{3250\times 4}{\pi\times 18\times 18} = 12.78\ \text{ft./sec.}$$

In this installation the penstock is embedded in concrete, a rise pressure of 30% can be consirered for preliminary calculations.

Head + water hammer = 340 ft.

1 Atm = 34 lbs. of water column

$$\text{Pressure} = \frac{340}{10}\times 14.2 = 142\ \text{lbs/sq. inch}$$

$$t = \frac{142\times 18\times 12\times 1.25}{2\times 16000} = 1.2''$$

$$\frac{D}{b} = \frac{18\times 12}{1.2} = 180$$

$a = 2780$ ft./sec.

The critical time

$$T_c = \frac{2L}{a} = \frac{2\times 625}{2780} = 0.4485$$

If the gates are closed within 0.4488 sec.

$$\frac{\Delta H}{H} = \frac{2780\times 12.78}{32\times 290} = 383.6\%$$

A pressure rise of 383.6% is too high for the pipeline. It would be necessary to decelerate the water column. In practice it is usual to have a closing time much longer than the critical value.

During the planning stage of a hydro-electric installation it is sufficient to employ simple short methods for calculations of surges. At present it is the common practice to have one penstock feeding one turbine. The calculations given hereunder apply to such a case.

In water hammer calculations one theory propounded is called the rigid column theory. In this it is assumed that water behaves like a solid rod. Any change in the gate movement is immediately felt at the forebay. The maximum pressure that will be reached is given by :

$$\frac{\Delta H}{H} = \frac{m^2}{2} \pm \sqrt{\frac{m^2}{4}+m^2} \quad \ldots\ (7)$$

where $m = \dfrac{LV}{TgH}$

T = closing time or opening time of the gates

\+ for pressure rise

– for pressure drop.

This equation gives fairly accurate values $T > \dfrac{4L}{a}$

The same equation is also sometimes represented by

$$\frac{\Delta H}{H} = \frac{N}{2} \pm \sqrt{\frac{N^2}{4}+N}$$

$$N = \left(\frac{LV}{TgH}\right)^2$$

$$\left(\frac{\Delta H}{H}-\frac{N}{2}\right)^2 = \frac{N^2}{4}+N$$

$$\left(\frac{\Delta H}{H}\right)^2 = N\left(1+\frac{\Delta H}{H}\right)$$

With high head installations with long penstocks a pressure rise of 10-20% is generally adopted. With shorter lengths 30% can be considered. With penstocks embedded in concrete as in stations located near the dam, values as high as 40-50% have been used.

Reaction turbines with long penstocks, where relief valves have to be installed, a gate closing time of 2.5 to 4 secs. may be assumed in preliminary calculations.

Problem of pressure changes in Francis and Kaplan can be considered in the same way as the turbines are controlled by movable guide vanes. For purposes of load rejection Kaplan turbines can be considered as having fixed blades, because the time of closure of runner blades is several times longer than for guide vanes.

e.g. 1. The penstock is short and further it is

partly embedded in concrete, hence 30% pressure rise can be considered. Then

$$\frac{TgH}{LV} = 3.8$$

$$T = \frac{3.8 \times 625 \times 12.78}{32 \times 290} = 3.279$$

For deciding on the closing time the momentum of the waterway in the spiral casing has also to be considered :

$$V = \phi\sqrt{2gH}$$

$\phi = 0.2$ for high values of N_s (low head)
$= 0.14$ for low values of N_s (high head)

The length of the spiral case can be taken as 5 times diameter of the runner.

e.g. contd. : $V = 0.14\sqrt{2gH} = 19$ ft/sec.

$L = 5 \times 10 = 50$ ft

LV of spiral casing $= 19 \times 50 = 950$

LV of penstock $= 625 \times 12.78 = \frac{7988}{8938}$

Then $$T = \frac{8933 \times 3.8}{290 \times 32} = 3.66$$

Before determining the equivalent closing time of the gates for reaction turbines check should be made to ensure that a value will not be chosen which is so short as to result a rupture of the draft tube column. In the case of low head plants this criterion is the limiting factor for choosing a short closing time.

The draft tube surge generally reaches a maximum value of the point of no load or the maximum value of the speed rise. A maximum of 12 ft. vacuum can be taken for preliminary calculations. The velocity head can be assumed to be 10% of full load value.

Example 1 : In the example a check has to be made if the closing time will not break the draft tube column.

LV of draft tube $= \frac{4G}{D} = \frac{4 \times 3250}{10} = 1300$

Barometric Pressure $= 32$ ft
$H_{vap} = 1$ ft
$H_s = 5$ ft

Discharge velocity $= 0.2\sqrt{2gH} = 15$ ft/sec.

Velocity head $= \frac{v^2}{2g} = \frac{225}{2 \times 32} = 3.516$

Absolute pressure at point of maximum slump $(V_{ac} + H_{vap}) = 12 + 1 = 13$

Velocity head $= 0.1\frac{V_L}{2g} = \frac{0.3516}{13.3516}$

Total head $= 32 + 5 = 37$.

It is required to find out what closing time would produce a pressure change in the draft tube from 37 to 13.35

$$\text{Total rise of pressure in waterways} = \frac{(37 - 13.35) \times \text{Total LV}}{\text{Draft tube LV}}$$

$$= \frac{23.65 \times 10{,}240}{1300} = 186\%$$

$$\theta = \frac{LV}{SH} = \frac{10{,}240}{32 \times 290} = 1.104$$

For a pressure rise of 186% $\frac{TgH}{LV}$ from equation (7) is nearly equal to 1.

$$\frac{T}{\theta} = 1$$

$$T = 1.104$$

In the case of long penstocks the calculations differ somewhat. The method can best be illustrated by an example.

Example 2 : $D = 72''$ $Q = 447$
$L = 2900$ ft. $V = 15.87$ ft./sec.
$H = 1019$ ft. $HP = 48000$

For purposes of calculation of thickness of the penstock let us assume 15% pressure rise.

Head + pressure rise $= 1019 + 153 = 1172$

1 Atmosphere $= 34$ ft. of water column

Pressure $= \frac{1172}{34} \times 14.2$

$$t = \frac{1172 \times 14.2}{34} \times \frac{72 \times 1.25}{2 \times 16{,}000} = 1.4''$$

$$\frac{D}{b} = \frac{72}{1.4} = 52.29$$

$$a = \frac{4675}{\sqrt{1.5229}} = 3788$$

$$T_e = \frac{2 \times 2900}{3788} = 1.53 \text{ sec}$$

$$\frac{\Delta H}{H} = \frac{3788 \times 15.87}{32 \times 1019} = 184.5\%$$

As the pipeline is long 10% pressure rise can be taken

$$\therefore \frac{TgH}{LV} = 10.49 \text{ from eq. 7}$$

$$T = \frac{10.49 \times 2900 \times 15.87}{32 \times 1019} = 14.81 \text{ sec.}$$

It would be seen from the above example longer closing time would be required with the increase in the length of the penstock. If the closing time is increased the unit would run-away. If the time is reduced there would be an increase in the pressure rise, so it would be necessary to divert the water by providing a relief valve—a pressure regulator as it is called in the case of reaction turbines, and with impulse turbines a jet deflector is provided.

There are two types of pressure regulators—water saving type and water wasting type.

A water wasting type is designed to maintain constant velocity in the pipeline at all conditions of load. The opening of the regular is adjusted in proportion to the gate opening so that water not used by the turbine will be discharged through the regulator.

Water saving regulator is meant to open only when the turbine gates are closed rapidly. The relief valve always functions in combination with an oil pressure speed governor comprising a differential servo-motor for the distributor. The displacement of the governor piston is tied to the displacement of the relief valve piston that is to say the governor cannot under any circumstances, close rapidly the turbine distributor mechanism if the relief valve does not open by a corresponding amount. There is therefore no danger of excessive pressure rise in the pipe line as it is the opening of the relief valve which determines the closing of the distributor mechanism.

e.g. 2 : If the pressure rise in the penstock is to be kept at 10% and the gate closure 4 secs. a relief valve has to be installed

$$\frac{TgH}{LV} = 10.49 \text{ from equation 7}$$

$$\text{If } T = 4 \text{ secs.} \frac{gH}{LV} = \frac{10.49}{3} \text{ or } \frac{LV}{gH} = 0.286$$

The momentum of the water way is

$$\frac{LV}{gH} = \frac{2900 \times 15.81}{32 \times 1019} = 1.413$$

The quantity of water to be diverted i.e. relief valve capacity :

$$\frac{1.413 - 0.286}{1.413} = \frac{1.127}{1.413} = 80\%$$

The inertia of water in the turbine passage including the penstock and draft tube prevents prompt increase or decrease in the energy supplied to the turbine as called for by the governor, thus aggravating the speed changes.

The penstock

$$\eta = \frac{LV}{gH}$$

This value generally lies between 0.5 and 3.

The energy in a rotating Mass of the turbine and generator

$$\frac{MV^2}{2} = \frac{WV^2}{2g} = \frac{W}{2g}\left(\frac{2\pi RN}{60}\right)^2 = \frac{WR^2N^2}{5870}$$

WR^2 = flywheel effect

N = speed in RPM.

The energy change for a speed rise to N_2 from N consequent to load rejection

NS	20	35	50	75
K	0.98	0.96	0.92	0.84

$$= \frac{WR^2(N_2^2 - N^2)}{5870} \quad \ldots\ (8)$$

This eq. 8 equals to approximately

$$\frac{HP \times 550 \times 7}{2} \quad \ldots\ (9)$$

T = governor closing time

$$\frac{WR^2}{5870}(N_2^2 - N^2) = \frac{HP \times 550 \times T}{2}$$

rearranging

$$\frac{N_2}{N} = \sqrt{1 + \frac{3.2 \times 10^6 \times T}{C \times 2}} \quad \ldots\ (10)$$

If pressure rise also is taken into consideration eq. 10 would have to be modified.

$$\frac{N_2}{N} = \sqrt{1 + \frac{3.2 \times 10^6}{C} \cdot \frac{T}{2}\left(1 + \frac{\Delta H}{H}\right)^{3/2}} \quad \ldots\ (11)$$

$$\frac{N_2}{N} = 1 - \frac{\Delta N}{N} = \sqrt{1 + \frac{3.2 \times 10^6}{C} \cdot \frac{T}{2}\left(1 + \frac{\Delta H}{H}\right)^{3/2}} - 1$$

If the load is added suddenly there would be a drop in speed than the equation for speed drop :

$$\frac{\Delta N}{N} = 1 - \sqrt{1 - \frac{3.2 \times 10^6}{C} \cdot \frac{T}{2}\left(1 - \frac{\Delta N}{H}\right)^{3/2}}$$

Equations above apply for full load rejections or full load additions. For partial load additions or reductions of the major factor under the root should be multiplied by a part load factor ϕ.

For an impulse turbine for full load rejection the speed size can be approximated :

$$\frac{N_2}{N} = \frac{T \times 3.2 \times 10^6 \times HP}{2 \times 2 \times WR^2 \times N^2}$$

Values of speed rise for partial load rejections will be approximately as given hereunder :—

% of load	100	75	50	25	
% speed size as % of full load value	100	90	75	45	
Load change %	25	50	100		Francis
Speed rise % of full load value	25	45	100		Francis
Speed drop	30	50	—		Kaplan
Speed rise	30	55	100		Kaplan
Speed drop	40	60	—		Kaplan

The speed rise with full load rejection is also to some extent dependent on the specific speed. The factor 'k' by which the second component under the square root should be multiplied is given hereunder :

0.77	0.71	0.66	0.61	0.57
100	125	150	175	210

In instances when stability is the criterion of the flywheel effect, for normal speed governing the following values can be used :

Pelton turbines, Francis turbines with relief values $\left\{ \frac{1.6\ HP\ 10^6}{WR^2\ N^2} = 2.5 \right.$

Francis & Kaplan $= 3.0$

e.g. 1 : In this plant a speed rise of 30% can be considered. If a lower value of say 10% is taken a relieg valve may be necessary, with the attendent increase in costs of the turbine, generator and civil works. Now-a-days even higher values of speed rise is admissible. In the present case a rise of 30% is admissible which does not warrant a relief value.

Taking eq. (7) and a closing time of 5 secs.

$$1 + 0.3 = \sqrt{1 + \frac{3.2 \times 10^6}{C} \times \frac{5}{2} \times 1.3^{3/2}}$$

$$C = \frac{3.2 \times 10^6 \times 5 \times 1.3^{3/2}}{.2 \times 0.69}$$

$$= 13.66 \times 10^6$$

$$WR^2 = \frac{13.66 \times 10^6 \times 95{,}000}{187.5 \times 187.5} = 36.89 \times 10^6$$

With 'k' 0.92 WR^2 34×10^6

For a generator of 70 MVA, 187.5 RPM the total flywheel effect recommended would be of the order of 30 million. The WR^2 of the runner, shaft etc. would be of the order of 2 million. Taking into consideration that the formulae developed above for preliminary estimate purpose the WR^2 of 34 million should be fairly correct.

e.g. 2 : For restriction of the pressure rise a relief valve has been found necessary. So lower speed rise of 20% can be taken in this case.

$$C = \frac{3.2 \times 10^6 \times 2 \times 1.10^{3/2}}{0.44}$$

$$= 16.78 \times 10^6$$

$$WR^2 = \frac{16.78 \times 10^6 \times 48000}{600 \times 600}$$

With K = 0.97

$$WR^2 = 2.17 \times 10^6$$

The normal value is about 1.5 million for generator of this size. Such inaccuracies are possible as we have assumed that the output is changed by the governor along a straight line.

In conclusion it is necessary to point out that there are inherent inaccuracies in the speed rise formulae developed above. Several secondary factors affect the speed regulation. It has been assumed for simplicity that the power output at any instant is proportional to the gate opening, which strictly is not correct.

The windage and friction losses of revolving parts, head variation change of head due to change of flow, run-away speed are some of the factors which affect the speed change. The problem of speed control of turbines receiving water through a conduit is a very intricate one, requiring step by step lengthy computations for close and results when approximate values are sufficient the above equations can be used.

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Editorial

A World within the World

PRINCE PHILIP'S Seventh Graham Clark Lecture, published elsewhere in this issue is indeed stimulating. He has opened up a broad perspective before engineers in the Commonwealth, which was all along there and yet not so clearly conceived. Emerging out of the British Empire, the Commonwealth is a fascinating experiment. It is composed of nations spread out over all the continents and represent cultures and civilisations of many hues. The needs of each are peculiarly different from the rest because of the geographical situation, demographic contexts and cultural and economic milieu. And yet because of this grouping of unevenly developed societies, one is able to receive understanding help and cooperation from the others in meeting its problems. The Prince has indeed very admirably surveyed this whole canvas in the engineering setting, formulating the different problems and tasks. And he has done it in such an admirable way that a common outlook has emerged —one that is sympathetic and understanding. It was indeed most needed. Each country's engineers and administrators are desperately struggling to grapple with their specific problems and yet they now become aware of the problems and tasks that face their fellow engineers elsewhere. A smaller and a more inter-related world within the larger one looms from the Lecture—a world of fellow-feeling and cooperation. Let us trust that this spirit will be radiated more widely and in other fields as well.

To us the most crucial point raised by the learned speaker was the one relating to technical education and scientific research. His thoughts on the subject are most appropriate. The newly-freed countries had not, in their political enthusiasm, realised the full significance of these fields in the modern technology-oriented times. It is not merely number that counts; the trained man is today the pivot of the modern, highly interwoven, specialist society. Without a whole galaxy of such men and institutions, steeped in a tradition of search for truth, political independence is a glittering chimera. Dam construction, steel plants, heavy industry, etc. can be imported from outside, but ultimately the strength and vitality of growth of a community would come from the quality and quantity of education in all the varied fields in humanities and sciences. And this, in the last analysis, depends on the quality and sincerity of the first teachers in each field. It is here when the foundation is truly laid. Alas, we tend to forget this lesson in the rush for quick results.

It is in this respect that the Commonwealth countries can cooperate without limit and this is the one field which enriches both the giver and the taker. Let us hope that the countries concerned will plan their mutual cooperation in this sector without reservations, most imaginatively and most extensively.

* * *

The Report of the World Bank, from which extracts are published in this issue, also makes exhilerating study. Although purely a financial institution, the Bank has attained a stature from where one can gain a broad vision of steady reconstruction and development. It has become one of the most important instruments of bringing talent and human ingenuity and experience to where it is need most, irrespective of political boundaries, with the sole aim of uplifting the common man and helping him to help himself. The Bank has indeed been able to reflect the spirit and philosophy of its President Mr. Eugene Black, which combines sound economics and finance with development of natural resources and the missionary spirit of the twentieth-century specialist. From this angle the record is excellent. Its granting of loans to more and more countries, collecting the needed funds from countries which can afford, is indicative of the confidence the people have in the Bank. But more striking is its scheme of helping the countries to prepare their development plans and projects after a careful survey and estimate. These unique Bank reports for each country have indeed opened the eyes of its countrymen in terms of their economic tasks and possibilities. The Bank's latest scheme of training "development-technicians" and keeping them supplied with the necessary literature and trends in current thinking is yet another evidence of its far-reaching insight into the vital weak-spots of borrowing countries. These are indeed fields, which, we dare say, the Bank had not ever thought of entering in its initial stages. Indeed no bank, in the strict sense of the term, ever undertakes these essentially 'educational' responsibilities. That the World Bank has cared to do so speaks of its thoughtfulness, sensitivity and constructive approach that penetrates far beyond the realm of finance and economics.

Finally, the Bank should be congratulated for the happy consummation of the Indus Waters talks, ending in a Treaty between India and Pakistan, after years of exhausting, and sometimes exhasperating, discussions.

Our Contributors

H. R. H. The Prince Philip, Duke of Edinburgh K.G., F.R.S., Hony. Member of the Institution of Engineers, London, has shown outstanding interest in Science. His Presidential Address at the British Association for the Advancement of Science in 1951, which dealt with Britain's contribution to the development of science and technology during the past hundred years, was described as "a most discerning survey". His Conference on "Human Problems of Industrial Communities within the Commonwealth and Empire" was a great success. The Oxford University Press has published a volume of his 'Selected Speeches 1948-1955'.

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Mr. N. Venkata Row's articles on Hydraulic Turbines appeared in our March. July and August 1960 issues.

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THE ENGINEER IN COMMONWEALTH DEVELOPMENT *(Continued from page 18)*

EDUCATION Appendix 14. Commonwealth educational statistics.

	Source	Units	U.K.	Canada	Australia	New Zealand	South Africa	India	Pakistan
1. Total population, mid-1958	Unesco	millions	51.9	17.0	9.8	2.3	14.4	397	85.6
2. Total public expenditure on education (a)	Unesco	£ million (b)	691 (1957 58)	339 (1957)	87 (1958 59)	39 (1959 60)	63 (1958) (c)	163 (1958 59)	20 (1957 58)
3. (2) as a percentage of national income	Unesco	per cent.	4.0 (d]	3.9	2.2	4.1	3.0	1.7	1.3
4. Nnmbers graduating in science and technology (or cmpleting equivalent courses) in a year	High Commissioners	thousands	14.3 (1959) (e)	5.9 (1958 59)	1.9 (1959) (f)	0.38 (1959)	1.1 (1958) (g)	29 (1958)	3.2 (1958 59)
5. (4) as a propoation of total population	—	no. per million	280	349	190	160	77	72	37

Notes : (a) Generally includes capital expenditure ; (b) Converted to £ on basis of exchange rates ; (c) Excludes capital expenditure ; (d) Percentage in 1957 ; (e) Source : Mimstry of Education ; (f) Excludes postgraduate degrees (0.2), includes technical-college diplomas (0.7); (g) University degrees (bachelors' degrees and diplomas only) in engineering, mathematics, and pure sciences (Source : Annual report of Department of Education, Arts and Science, 1959).

PROFESSIONAL ORGANIZATIONS

Appendix 15. Constituent members of the Commonwealth Engineering Conference

The Institution of Engineers, Australia
The Engineering Institute of Canada
The Institution of Engineers, Ceylon
The Institution of Engineers, India
The New Zealand Institution of Engineers
The Institute of Engineers, Pakistan
The Rhodesian Institution of Engineers
The South African Institution of Civil Engineers
The South African Institute of Electrical Engineers
The South African Institution of Mechanical Engineers
The (U.K.) Institution of Civil Engineers
The (U.K.) Institution of Mechanical Engineers
The (U.K.) Institution of Electrical Engineers

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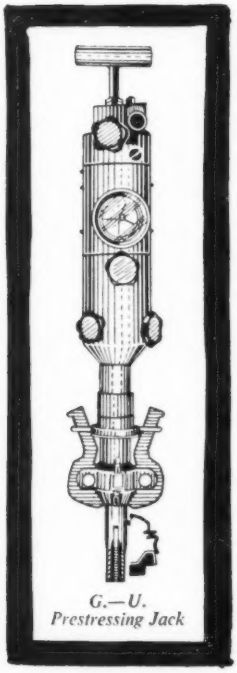

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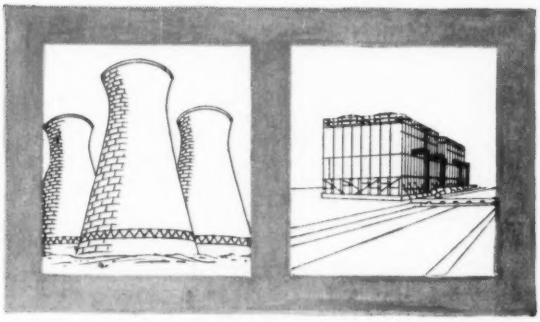

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